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An Inquiry into the Composition of  
Dietaries, with Special Reference to  
the Dietaries of Munition Workers.



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1918

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MEDICAL RESEARCH COMMITTEE.

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An Inquiry into the Composition of Dietaries,  
with Special Reference to the Dietaries of  
Munition Workers.

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*(Approved for publication by the Medical Research Committee,  
7th December, 1917.)*

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## INTRODUCTION.

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The Committee are indebted to the Ministry of Munitions for permission to publish the present Report upon the dietaries of munition workers. To the inquiry of which the results are now to be given the Committee were able to give some assistance in its early stages, and for the general work of the Food Investigation Committee appointed by the Minister of Munitions the Committee have been glad to lend the services of Dr. Leonard Hill, Director of their Department of Applied Physiology.

The Report has obvious and immediate value in supplying data of primary importance to those who have to solve the social and administrative problems of rationing the civilian forces of the country. Apart, however, from this relation of the authors' collected information to the present emergencies, their results definitely add to our general knowledge of the actual dietaries of our population. They have summarised the available information obtained before the war as to the dietaries of workers and their families, and they give also, for comparison with their own figures, the main results of the investigations of working-class dietaries made during the war and before the rationing periods of 1917 which were carried out by Miss Ferguson working in Glasgow on behalf of the Medical Research Committee, and by Dr. Leonard Hill for the Health of Munition Workers Committee.

It will be seen that the authors have, as they say, "taken the liberty to prefix" to their Report an outline of the modern developments of nutritional physiology, in order that the reader "may be able to see the facts in their just perspective." The Committee welcome this addition to the Report of a preliminary statement giving the chief positions which have been reached by recent experimental enquiries; they have no doubt that it will be generally regarded as adding greatly to the usefulness of the Report, not only for the aid it will give to many in the interpretation of the facts presented, but also as offering a summary of modern dietetic investigations not easily to be found in such convenient form elsewhere.

It usually happens in the progress of scientific knowledge that periods of great activity in the collection of new facts alternate with others of discussion and consolidation. The coming of war caught the study of nutrition in a period of the former kind. The sudden and exceptional demand for practical guidance which sprang from war conditions found many gaps in the body of knowledge actually available for practical use in dietetics. When the food shortage became imminent, physiologists were able in some degree to state in quantitative terms

the actual energy consumed in this or that kind of productive work. They were not able, however, to assess at all fully the adaptability of the human machine. Its demands and its possibilities had been laboriously studied under conditions which circumstances had led us to consider as normal, but exactly how far the machine is capable of being adjusted to other and, presumably, less favourable conditions was less well known.

Those who are daily engaged in the close experimental study of particular aspects of the subject of nutrition are perhaps not always the best qualified to appraise and explain the bearings of present knowledge as a whole on the problems of practice. The present Report gives a critical exposition of this kind by writers who bring to the task the requisite knowledge and at the same time a desirable detachment. Since the quantitative element is so important in the issues involved, and since the experimental data need analysis, the mathematical authority of the authors adds much to the value of what they have written.

The Committee would venture to associate themselves with the authors in their expression of thanks to the various members of their staffs for their assistance in the severe tasks of collecting the necessary data for this Report, and at the same time to acknowledge their own indebtedness to the Welfare and Health Section of the Ministry for these results of some of the organised and scientific work of that Department.

31st December, 1917.

MEDICAL RESEARCH COMMITTEE,

15, Buckingham Street,

Strand, W.C. 2.

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# AN INQUIRY INTO THE COMPOSITION OF DIETARIES, WITH SPECIAL REFERENCE TO THE DIETARIES OF MUNITION WORKERS.

By

VISCOUNT DUNLUCE and CAPTAIN M. GREENWOOD, R.A.M.C. (T.)  
(*Welfare and Health Section, Ministry of Munitions*).

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## I. INTRODUCTION.

This report is based upon information collected by us since May, 1917, in hostels catering for munition workers. The work has been carried out under the supervision of the Food Investigation Committee, appointed by the Minister of Munitions, but the time has not yet come for the Committee to express a final opinion upon the serious questions involved. We are, however, permitted to describe the work so far completed, and to indicate the conclusions which we personally are disposed to draw from the facts disclosed.

The Committee does not, of course, accept any responsibility for these opinions, and we desire to express our thanks to it for permission to use the data.

## II. MODERN EXPERIMENTAL WORK ON DIETETICS.

Although the original object of this inquiry was merely to ascertain how much food was consumed by representative samples of munition workers in the summer of 1917, we think

that a mere compilation of statistics would have little public interest unless we also tried to show how far the statistical results are consistent on the one hand with an adequate provision of energy, and on the other with due observance of economy in face of a world shortage. We have thus been led to examine the development of scientific opinion respecting diet. Although many books have been devoted to the subject in recent months, we are not acquainted with any which contain precisely the information which we think the reader ought to have in order to be able to see the facts in their just perspective. On this account we have taken the liberty to prefix to our report on new data a rough sketch of modern physiological inquiries; naturally, this sketch is no more than a crude outline of the subject.

What may be called the *qualitative* facts of metabolism (*i.e.*, the transformation of energy within the living body) were definitely ascertained many years ago (references to the classical papers will be found in any good treatises such as those of Voit, Tigerstedt and Rubner). We mean by qualitative facts such results as:—

- (a) The energy needed for the performance of muscular work, whether work in the popular sense or that of the heart and other internal organs of the body, must be provided in the food, just as the energy transformed by a steam engine or a motor car must be provided in its fuel. From this point of view all foodstuffs, Carbohydrates, Fats and Proteins, can be compared on the basis of the amounts of energy they liberate when transformed in the body. The common measure of this energy is the heat equivalent—that is, the number of *calories* of heat liberated in the combustion. (A large calorie is the amount of heat needed to raise the temperature of 1 kilogramme of water 1° C.).
- (b) The repair or growth of the body is likewise effected by means of substances taken in the food, but, for this purpose, only one class of substances, *the proteins* (complex bodies invariably containing the element nitrogen as a constituent), is available.

These qualitative statements need to be slightly modified in view of what has been discovered within the last 25 years. Thus it is possible to meet the tissue repairing and growth requirements of a living animal without supplying native proteins.

Native proteins are split up within the body into *relatively* simpler substances, and these simpler substances can replace native proteins in the diet. Although the fact is of importance as explaining why certain native proteins are more nutritious than others (they are so because the products of their decomposition can be more easily worked up into our own tissues), it is still *practically* essential to feed animals upon natural proteins, under the normal conditions of life.

Another qualitative fact which has been brought to light or, to speak more accurately, made clearer by modern work, is the necessity for including in the diet small quantities of unanalysable substances, present in greater or less degree in fresh foodstuffs, which are termed *vitamines*. The absence of these substances leads to illness or death,\* and their presence gives various articles of diet, such as salads, fresh fruit, &c., an importance not to be measured in terms of calories.\*

We might add, although this is not a recent discovery, that the diet must also include inorganic salts, chlorides and phosphates. A deficiency of these is, however, hardly conceivable in civilised states.

We now pass to the quantitative side of dietetics, and inquire how much of the various ingredients or how many calories are needed by the human adult under various assigned conditions of life.

As long ago as 1859 Moleschott constructed standards from a statistical analysis of diets, and years earlier, such illustrious men of science as Laplace, the mathematician, and Lavoisier, the chemist, carried out experiments which might be regarded as a starting point in the attempt to measure food requirements; but the first inquiry which really focussed interest upon the matter was that of Voit, the eminent German physiologist. Voit's results were described in an address delivered to a medical congress at Munich in the year 1875, published in the *Zeitschrift f. Biologie* of 1876,† and since quoted by innumerable authors, a small percentage of whom have even consulted the original paper. Voit, in collaboration with Forster, collected statistics of dietaries chosen by people living under different conditions, and he measured the heat production of a few men consuming different known amounts of food and doing different measured amounts of work in a special chamber. He concluded that a man of moderate weight (he did not always take the same weight, but the figure of 70 kilogrammes, or about 154 lbs., is usually adopted by German writers), doing a moderate day's work (by which Voit understood the sort of day's work done by a carpenter, something more physically strenuous than a tailor's work, and less so than that of a blacksmith), needed 118 grms. of protein and 328 grms. of carbon in his daily ration. The protein must, of course, come from protein in the food, but the carbon might be provided either in carbohydrate (starchy or sugary food) or in fat. Regarding the proportions of these latter ingredients, Voit expressed himself as follows:—"According to my observations workmen should receive not more than

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\* The most recent and practical study of *vitamines* is that of Chick and Hume, *Journ. Roy. Army Med. Corps*, August, 1917; it contains all the information the reader is likely to need, expressed in clear and non-technical language.

† Vol. XII, p. 1.

500 grammes of starch, for a larger quantity is only utilised with difficulty by the digestive organs, so that other inconveniences arise.

“The remainder of the carbon should then be furnished from fat, in effect 56 grammes of fat to 500 of starch. This is, in my opinion, the maximum quantity of starch and the minimum quantity of fat a workman ought to consume. I even think it would be better to supply only about 350 grammes of carbohydrate, and the remaining requirements in the form of fat.”\*

It is clear from the above that Voit was, in 1876, not enamoured of the ration of 500 grammes of carbohydrate for the average labourer, but his opinion on this point subsequently changed.

In 1881 he wrote the article on metabolism in Hermann's *Handbook of Physiology*. In the section of dietaries, the passage above quoted is reproduced almost word for word down to the end of the sentence concluding with “500 of starch.”

But the subsequent sentence is replaced by these words:—  
“I think it is preferable in the case of those not actually working with their hands, to give only about 350 grammes of carbohydrate and the remaining requirements as fat; as a general rule, the diet of the well-to-do classes contains both absolutely and relatively more of the dear fat and less of the bulky carbohydrates.”†

On a later page the ration of 118 grammes of protein, 56 grammes of fat and 500 grammes of carbohydrate is tacitly adopted and defended by Voit as a standard diet for moderate muscular work.

This standard, based upon a small collection of statistics and a smaller number of confirmatory experiments, may properly be called Voit's standard. It has enjoyed a vogue which is not so much due to the number or accuracy of the laboratory experiments carried out by Voit as to this investigator's high and well deserved reputation.

Between the publication of Hermann's *Handbook* and that of the next large German treatise on physiology (edited by Nagel in 1909), the most important contributions to the subject were made by Atwater and his collaborators in America, and by Rubner and his pupils in Germany.

The work of the Americans did not differ in kind from that of Voit. They also collected statistics of actual dietaries and made experiments on men under observation in laboratories.

But both experiments and statistics were more numerous and exact. Atwater, indeed, brought the technique of calorimetric experiments to a high pitch of perfection. By calorimetric

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\* *Op. cit.* p. 22.

† Hermann's *Handb.*, Vol. VI, Pt. I, p. 520.

experiments we mean observations upon men living and working in closed chambers under conditions admitting of very precise measurement of the heat transformed or liberated within the chamber.

In the end Atwater reached a standard which provided for a man under the conditions assigned by Voit—125 grammes of protein, 125 grammes of fat, and 400 grammes of carbohydrate. The energy equivalent of this diet is 8 per cent. higher than that of Voit (3,315 calories instead of 3,055), and the distribution between fat and carbohydrate quite different from that of Voit's ultimate prescription.

The American standards have varied somewhat in different publications, and to illustrate their exact significance we shall now quote from Bulletin No. 84 (1900) of U.S. Department of Agriculture (p. 14):—

“By comparing the results of dietary studies and of experiments upon the physiological demands of the body as studied by means of metabolism experiments, and in other ways, investigators have endeavoured to establish dietary standards based in part upon the observed facts of consumption and in part upon physiological data. In general, the amounts of nutrients consumed by a man at ordinary muscular labour are less than would satisfy a man at severe work, and more than are required by a man at very light work, or a professional man of sedentary habits. According to assumptions based upon such data the standards shown in the following table are estimated.

*Tentative Standards for Daily Dietaries*  
(Atwater).

	Protein. Grammes.	Energy. Calories.
Man with very little physical exercise ...	90	2,500
Man at light work ... ..	100	3,000
Man at moderate muscular work ... ..	125	3,500
Man at active muscular work ... ..	150	4,000
Man at severe muscular work ... ..	180	5,700
Man at very severe muscular work ... ..	200	7,500

“The amounts of fats and carbohydrates required are not stated in the table, because it is considered that theoretically they can replace each other in the diet in proportion to their fuel value: 1 gramme of fat being equivalent as a source of energy to  $2\frac{1}{4}$  grammes of carbohydrates or protein. Thus, while a certain amount of protein is necessary in a dietary, the amounts of fats and carbohydrates may be governed by circumstances, so long as the sum of their fuel values added to that of the protein gives a total fuel value equivalent to the requirements of the body. The standards in this table are those which have

been found to agree with American habits, and are somewhat more liberal than those adopted by European authorities. They are to be understood simply as tentative estimates of the protein and energy requisite under certain conditions, and in no sense to be considered as final."

A summary of the statistical evidence referred to \* in the passage just quoted is to be found on p. 66 of *Bulletin* No. 75, which records observations upon five athletic teams, 15 college clubs, 14 mechanics' families, 10 farmers' families, and 14 families of professional men, while in *Bulletin* No. 149 (a later publication) are statistics of the dietaries of Maine lumbermen (people doing perhaps the severest muscular work in the world), and numerous other additions have been made to the general statistics since 1900. The most important of the experimental studies referred to are described in *Bulletin* No. 109, and relate to calorimetric observations upon four subjects (none of whom was a skilled labourer) under various conditions.

The statistical data are more accurate (so far as quantity and composition of the food are concerned) than any others yet published, and the experiments models of exact work. Nevertheless, the basis of facts does not support any more definite conclusions than are to be found in the quotation, which is meticulous in the caution with which generalisations are made.

The above passages contain, we think, a sufficiently accurate account of the fundamental American contributions to the subject of pure dietetics. Of course the American investigators have published many other papers of great scientific interest and importance upon special topics. These, however, are not, as a whole, directly relevant to anything with which we are now concerned.

The contemporaneous work of Rubner and his pupils in Germany, a good general description of which will be found in Rubner's article, "Ueber moderne Ernährungsreformen," which appeared in the *Arch. f. Hygiene*, vol. LXXXI, 1913, p. 179 (this being the most recent pre-war utterance of Rubner, we regard it as the authoritative expression of his views), was similar in many ways to that of Atwater and his associates in America. It was less avowedly utilitarian and, as is usual in German work, the main line of inquiry was more frequently diverted to follow up side issues of theoretical interest.

We owe to Rubner and his colleagues an elucidation of the respective rôles of protein, fat and carbohydrates as sources of energy as well as very exact determinations of their combustion values; these investigators have also placed the study of minimum protein needs, if not upon a correct, at any rate upon an intelligible

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\* The complete record down to 1910 covers 445 studies, involving 13,031 persons, but of these only 391 seem to have been industrial workers; see Appendix II.

basis. Of the protein question we shall speak later. So far as calories are concerned, Rubner's position is not essentially different from that of Voit, 30 years before, nor does he provide any specially important new statistics. Recalculating Voit's standard (having made certain technical modifications required by a minuter knowledge of combustion values), Rubner brings it into the form of 111 grammes protein ; 60 grammes, fat ; 500 grammes, carbohydrate ; of total energy 3,059 calories. His own measurements and statistics lead to a standard of 3,121 calories, which is practically the same as Voit's, and he displays a certain pugnacity in defending the Voit (or Rubner) diet against the onslaughts of those who advocated either fewer calories or less protein.

It does not, however, appear that Rubner's actual basis of statistics and experiments was in any way more substantial than that of Atwater and his colleagues, or that any finality in judgment was permissible. The American writers (usually quoted at second hand) have figured more prominently in popular English literature than the Germans (who are almost invariably quoted at second hand). Through this process of quotation and re-quotation, the original cautions and reservations disappear.\* We have to reconcile a quite considerable discrepancy between the number of calories estimated as needful for the same type of work by investigators using similar methods of inquiry. How is it that the Americans suggest 3,500 calories, while the Germans are content with some 3,100 ?

The explanation is simple when we realise that the standards are after all based upon limited statistics, and that "moderate work" is quantitatively undefined. In freely chosen diets, the habits and customs of different nations play a great part, and climatic conditions are even more important. Then also, we find no common measure of what constitutes a moderate day's work.

The vague qualitative idea of a day's work which is more than that of a tailor and less than that of a blacksmith might be acceptable within one country, but it is unreasonable to assume that blacksmiths in Germany and America do the same amount of work daily.

Nobody budgets for the petrol he requires to run his motor car from London to York by hazily thinking that he is going beyond Barnet but not as far as Caithness. The efficiency of

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\* The habit of quoting at second hand is amusingly illustrated in an example noticed by Benedict and Cathcart in their treatise on "Muscular Work." In the text, p. 103, the English physicist, Joule, is given as authority for an estimated efficiency of the muscles of 25 per cent. In a footnote we read that Joule's value is cited from a paper by Hanriot and Richet in the *Comptes rendus* of the French Academy of Sciences, while Hanriot and Richet themselves cited Joule from a German treatise by Fick. What Joule really said and where he said it remain undisclosed. Medical literature is full of these indirections.

the engine can be accurately determined and its requirements precisely known. It may not be possible to define the requirements of the human machine with equal precision; indeed, it certainly is not possible,\* but this fact alone ought to restrain us from attaching great importance to theoretical standards of diet.

We shall now consider the special energy requirements for work in the light of experimental data. The problem may be enunciated as follows. It is required to ascertain how much energy is transformed by a man of assigned weight when absolutely at rest, and how much further energy is transformed when he does a definite amount of muscular work.

A man absolutely at rest (say quietly sleeping) needs enough energy to maintain his body temperature within narrow limits, and a further quantity to cover the work performed by his heart in pumping blood through the vessels, by his glands in secreting the substances necessary to maintain the composition of the circulating fluids, by his kidneys and bowels in excreting waste products, and by his respiratory organs in performing the office of bringing oxygen into the lungs and carrying carbonic acid gas away from them. The necessary amount varies with (*a*) the external atmospheric conditions, and (*b*) the mass of the body.

So far as (*b*) is concerned, the point is that the surface of the body, from which heat is lost, does not increase at the same rate as the mass, so that if the weight is doubled the surface is not. Much ingenuity, both mathematical and experimental, has been devoted (by Meeh, Bouchard, Roussy, Lefèvre and many others), to ascertaining the exact relation. We find, however, from an analysis of various statistics that the influence of body weight can, for men between 50 and 70 kilos. in weight, be expressed with quite sufficient accuracy by a simple linear relation, and so need not discuss the technical details of the formulæ.†

This is the justification of the method adopted by most physiologists of expressing the energy requirements of a resting man at so much per kilo. of body weight. It would be quite wrong to apply this formula to compute the heat requirements of a living skeleton or of a fat woman in a show, and, even worse, to use it for children, but it is sufficiently accurate for the range of normal adults. Many experiments have been made on professional fasting men, like Succi, hysterics, and normal persons asleep, with the result that the average requirements are about 1 calorie to the kilo, an hour during sleep, and as much as 20 per cent. more for the resting man while awake. Hence a 70 kilo. man needs some 1,650 to 2,000 calories at room temperature,

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\* See Appendix I.

† Thus an expression of the form  $H = aW + bM + c$  where *a*, *b* and *c* are constants, effectively represents the relation of heat, work and mass, for fairly wide ranges of mass. See Appendix I.

*i.e.*, at a temperature of 65 to 70°F., and when not exposed to moving air.

So far we have reckoned (*a*) as constant. Vary the condition, lower the external temperature, or, especially, increase the movement of the air to which the resting man is exposed, and the demand goes up and may be enormously increased.

The first half of the problem is thus approximately solved,\* and we come to the second. Here we meet an insuperable difficulty.

A large number of extremely accurate experiments have been done on the energy transformation of men doing known amounts of work on bicycles. From these experiments we can calculate with nicety the extra amount of energy needed for each increment of work done, *starting from a definite minimum*, the calculation being a very simple one. This is illustrated in Table I, which refers to experiments done by Benedict and Cathcart on a bicyclist, pedalling at the rate of from 68 to 73 revolutions a minute against increasing resistances, and the formula (which we deduced by a statistical process) agrees with the observations extremely well. For every extra calorie of work, the cyclist needs 3·343 calories of energy. His efficiency within the range is therefore 29·9 per cent., which is far higher than that of any steam engine.† But this formula tells us nothing whatever about the requirements *below* the minimum, which is a high one. If we put the work equal to zero in the formula we deduce an energy requirement of 2·41 calories a minute, or (as the man weighed 66 kilos.) 2·2 calories an hour per kilo., which is enormously greater than the observed output of this particular man while resting (this was about 1·06 calories per kilo. per hour). The point is that there is a hiatus between the man at rest and the man working hard on the bicycle. When he is not asleep, but sitting or walking, he is doing muscular work of which we have no quantitative measure. We have no satisfactory measurements of the relation between work and energy for very small amounts of work.

There is some evidence that the increase is not constant, and may even be discontinuous, but we shall not discuss it here.‡

Very few observations equal to those on the bicyclists in technical accuracy have been made under factory conditions. The only ones of recent date are those of a French scientific man, Dr. Jules Amar. Amar investigated the energy transformed by a metal filer working at the rate of 70 strokes with the

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\* But *only* approximately, for it is easy to collect *individual* cases of life, even active life, being maintained upon an intake of less than 1 calorie per kilo. per hour over long periods.

† Untrained persons doing similar work return about 25 per cent. of the increment of heat in work.

‡ See Appendix I.

file per minute.\* The workman was an experienced operative, 38 years old, weighing 74 kilos. (163 lbs.). It was found that the man did work equivalent to 20·8 calories in an hour, the heat transformed or liberated in his body during the hour being 290·5 calories. From this it follows that if he worked for eight hours at just this rate, and if he slept for eight hours, and rested or lounged the remaining eight hours, his total heat production would be 3,656 calories. To reach this result we have supposed that during work the heat production is what Amar observed, that during sleep it is 1 calorie for each kilo. of body weight an hour, and during waking life, apart from the work period, that it is  $1\frac{1}{4}$  calories per kilo. an hour, a low estimate.

This daily output is very nearly the same as the American standard for moderate work, but we think that the actual effort assumed here is more than a moderate day's quota, and might even be deemed "active" muscular work. Thus it is 11 per cent. more than the average work done by metal filers in  $8\frac{1}{2}$  hours, according to Amar's estimate, and,† in any event, metal filing is a sufficiently strenuous occupation.‡

To summarise, we draw the following conclusions :—

- (1) Exact measurements of the energy transformed in doing certain kinds of muscular work enable us to determine the increase in demand for energy with increasing work, the body weight of the subject being known, with fair accuracy, but only within comparatively narrow limits. From such experiments we can draw no conclusions respecting the requirements of a man doing sedentary work.
- (2) Current dietetic standards of energy needs are ultimately based upon statistical averages deduced from a sampling of diets actually eaten ; their validity is not finally established by exact experiments.
- (3) External conditions exercise an enormously important influence on the energy demand.

We now pass to the other aspect of the question, which has been the subject of interminable discussion, viz., the necessary amount of protein in the diet.

We do not need to devote a great deal of space to this matter, because modern investigations have deprived much of the earlier work of the importance it seemed to possess.

So far as writers upon dietetics are concerned, the discussion has raged around the question, What is the minimum amount of protein necessary to maintain a man of assigned weight in

\* Amar, *le Moteur humain*, Paris, 1914, p. 527.

† *Op. cit.* p. 547.

‡ More so than the automatic or semi-automatic work of the lathe operative.

nitrogenous equilibrium? That is to say, how much must be taken to maintain his "flesh" constant? The point is, as we explained at the outset, that the necessary nitrogen can only come from protein in the food.

The outcome of the discussion is that there is no such thing as a fixed nitrogen minimum. This conclusion was seemingly first reached by Rubner, who at least has the credit of formulating the problem in intelligible terms. Shortly, his position is that the nitrogen demand must be stated in terms of energy—that, in fact, an equilibrium can be maintained so long as from 5 to 6 per cent. of the total calories in the diet are furnished from protein. This amounts to saying that a minimum can be reached with an adult man (sedentary work) on an intake of 30–35 grammes of protein daily. He also pointed out that this specific figure was meaningless unless the form in which the protein was taken was stated.

For instance, he brought a 70-kilo. man into equilibrium with but 25–35 grammes daily of animal protein—using potatoes 38·7 grammes were required, using bread as much as 84 grammes were necessary.\*

In a sense, therefore, the problem is solved, but (1) when the minimum protein need is placed upon an energetic basis (*i.e.*, stated in terms of calories allocated to different constituents of the diet) we are brought up against the difficulties already encountered in fixing a standard of energy requirements.

(2) There is no experimental evidence to decide whether healthy life can be indefinitely maintained at a low level of protein metabolism, *i.e.*, with so small a proportion of the energy value as 5 per cent. derived from protein in the food. *Statistically* it is clear that most European and American dietaries yet analysed provide more than 10 per cent. of the energy value as protein, while McCay † has demonstrated that in the East the fighting and working races habitually consume large quantities of protein, especially animal protein.

Before we leave the experimental part of the subject, we should mention that, merely as a source of energy, protein is not strictly interchangeable with carbohydrates and fats.

In the first place, the work of Rubner suggests that only a certain proportion of the calories liberated in the metabolism of

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\* The above is summarised from Rubner's memoir in *Archiv. für Hygiene*, Vol. 81, 1913, p. 202, &c., where citations of Rubner's other papers on the subject will be found. The observations of Rubner's pupil Thomas (*Arch. f. Physiologie, Jahrgang*, 1909, pp. 219–302) give a nitrogen minimum of 5·53 grms. (say, 34·6 grms. protein) daily with potatoes and of 13·07 grms. (say, 81·7 grms. protein) with wheaten bread. Merely as a source of protein, 1 lb. of bread is not biologically (as it is analytically) equivalent to 4·6 lbs. of potatoes, but only to 2·3 lbs.

† *The Protein Element in Nutrition*, London, 1912.

protein and fat are available as sources of work. Roughly speaking, all the calories liberated in the combustion of carbohydrates might be used to produce work ; only 87 out of every 100 calories liberated in the combustion of fat are so available, while only 69 out of every 100 calories from protein are capable of conversion into any form of energy other than heat. This helps to explain why a fasting animal can be brought into equilibrium (*i.e.*, to a state where it neither gains nor loses weight) on a smaller allowance of calories with a mixed diet than when only protein food is supplied.\*

It also throws light on the fact that the body burns carbohydrate in preference to fat or protein when muscular work is to be done. There is some basis for the popular belief that carbohydrate (sugar and starch) is the best food for muscular work.

In the second place, and indeed in continuation of what has just been said, there is reason to think that the ingestion of protein directly stimulates cellular metabolism. It is a very old aphorism of physiology that the consumption of protein is largely determined by the supply, *i.e.*, that the more protein given, the more broken down by the body. We do not propose to discuss the developments and modifications of this doctrine in modern time—to do so would lead us into technical difficulties. We shall try to convey the spirit of modern teaching under guise of a metaphor.

When the body lives on itself, it is rigidly economical. So soon as its ready money (the normal reserve of carbohydrate in the liver and muscles) has been spent, and the first class securities in its bank (the body fat) have also been realised and spent, it reduces its establishment. The less vitally essential cells are allowed to fall in pieces, and the ruins used to stoke the furnace for which no fuel can be purchased. But if the body is given building material (protein), it passes directly from pessimistic economy to optimistic schemes of reconstruction.

The demolished cells are rebuilt without regard to the fact that this will again increase the demands for mere fuel of the body as a whole. Hence it may happen that a supply of protein will paradoxically not satisfy but increase the cravings for food, because it will lead to the re-formation of cellular units which will then demand supplies of energy, rather than be itself used only as fuel for the reduced establishment. In ordinary life this tendency might be passed over as merely a curious fact. But were we to be dealing with rationing in its extreme sense—that is, of determining how much we can reduce the intake of food without endangering health and efficiency—we might have to reckon seriously with the tendency. A carbohydrate or fat minimum combined with

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\* The validity of this conception of Rubner's, so far at least as it involves an absence of specific dynamic action from carbohydrate feeding, has been justly called in question by the results of Lusk and his pupils. *Vide* Lusk, *Science of Nutrition*, 3rd edition, London, 1917, pp. 240 *et seq.*

a relatively high intake of protein might be a more dangerous state than a protein minimum with normal allowance of fat and carbohydrate. Similarly, a sudden reduction of diet is more hardly borne by those accustomed to a high protein intake than by the habitual consumer of a relatively low protein diet.

We are conscious that this attempt to distill the essence of an obscure matter is likely to be unsuccessful. The importance and extent of such variations in cellular mass as are here in question may well be slight. On this account, we abstain from further discussion of the subject.

### III. THE STATISTICS OF WORKING-CLASS DIETS COLLECTED BEFORE THE WAR.

The most extensive modern data relating to England are, firstly, those of Rowntree, published in 1902, and reporting the experience of several families in York in the year 1900 ;\* secondly data collected by the Board of Trade and referring to the year 1904.†.

The former material is better documented, but the latter is derived from much larger samples (1,944 families in all). Tables 2-4 contain an analysis of the returns from the physiological point of view. So far as the Rowntree results are concerned, our figures differ sensibly from those published by Rowntree himself in several instances, the explanation being (apart from any undetected errors of arithmetic in his or our reductions) that the analytical data used by Rowntree were not the same as ours. We always use the Food Committee of the Royal Society's values,‡ or when these do not apply to the articles consumed, the data of Atwater and Bryant.§

All our results are expressed as "man values," the scale chosen being that of the American observers provisionally adopted by the Food Committee of the Royal Society.|| In reducing the Board of Trade data other difficulties were encountered. We

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\* Rowntree, *Poverty : A Study of Town Life*, London, 1902.

† Report of an Enquiry by the Board of Trade into Working-class Rents, &c., 1913, Cd. 6955, p. 300.

‡ *The Food Supply of the United Kingdom*, 1917, Cd. 8421.

§ *Chemical Composition of American Food Materials*, U.S. Department of Agriculture, Bulletin No. 28, revised edition, 1899.

	Ages.	Man value.	
	0-5		.4
	6-9		.5
	10-13		.6
		Males.	Females.
	14-15	.8	.7
		Males.	Females.
	16 and over	1.0	.8

This method of reduction is not endorsed by all physiologists. We do not discuss the requirements of growing children here ; reference should be made to Appendix II.

have assumed that the constitution of the population was two adults, husband and wife = 1.8 men, and added to these  $\cdot 51 \times$  the number of children,  $\cdot 51$  being the weighted average man value of children (on 1911 population).

The Board's return does not separate flour from bread; we have given the combined quantities seven-eighths of the value of the same quantity of flour. Rice, tapioca and oatmeal are not distinguished.

We have taken the analytical composition of rice (which is intermediate between that of the other articles) as applicable to the combined quantities.

If the tables are compared, it will be noticed that on the whole the Rowntree returns contrast favourably with those of the Board of Trade; some of the poorest class budgets are below the Board of Trade level, but the better-paid families seem to have consumed, or at least to have purchased, food of energy value exceeding the conventional standards to an appreciable extent. The same remark applies to the specimens of diet supplied to persons of the servant-keeping class. The amount of fat in their diets and in some of the diets in Class 2 is large, and we shall not see comparable instances until we examine the war-time diet of munition workers. We do not think, however, that any statistical generalisations ought to be based upon such a small collection of instances.

The Board of Trade results are statistically much more important. We think it probable that some other articles of appreciable energy value (such as lard) were consumed over and above the quantities scheduled, and there is always the difficulty of choosing correct factors for families, the members of which are not recorded in age groups. On the whole, however, our reductions probably represent the facts with reasonable fidelity. It will be noticed that there is a steady increase of energy with increasing income, and we shall see later that there is a regular change in the proportionate distribution of energy derived from different constituents of the diet.\*

Here we must remind the reader of an important point in judging diets. In the previous section we have looked at the matter from the point of view of food actually consumed; but these data do not give us that, but the quantities of food purchased. Between purchase and consumption there is an element of waste. Waste in the culpable sense of deliberately spoiling or throwing away edible food is of hardly more than rhetorical interest; it has no sensible importance from the practical point of view. But there is an unavoidable waste of calories and protein in the preparation of food. This proportion is very small, almost

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\* For a good general criticism of the statistics of diets see Slosse & Waxweiler's *Enquête sur le Régime alimentaire de 1065 Ouvriers belges*, Solvay Institute, Brussels, 1910. Their dates are summarised in Appendix II.

negligible in the case of such substances as bread—here it is hardly more than the wasted crumbs and an occasionally forgotten crust which is too hard to masticate—but it is larger with green vegetables, potatoes and fat meats. Usually one reckons a wastage of about 10 per cent. in measuring the difference between food purchased and food consumed; we have no reason to impugn this calculation when applied to an ordinary diet. But when the food purchased contains much fat, we may anticipate that the waste is greater. From the energy standpoint a diet rich in fat (which in practice nearly always means a diet rich in butcher's meat and bacon) is usually a relatively wasteful diet. Consequently, in comparing statistical diets with theoretical diets, the reader should (unless the statistics are explicitly stated to refer to food consumed, as in the example about to be quoted, but in no others of our series) mentally subtract 10 per cent. from the former. If we also take account of differences in absorption within the body when different classes of food stuff are used, this discount might be increased to 12 per cent. (*see Appendix II*).

We may bring into comparison with our pre-war statistics the results of a small scale but very thorough investigation carried out by Miss Ferguson and her collaborators in Glasgow University.\* Miss Ferguson has contrasted the diets of 40 Glasgow families in 1911–12 and in 1915–16. The results, expressed in man values and terms of food *consumed*, were 3,163 calories and 110 grammes of protein in 1911–12, 3,298 calories and 102 grammes of protein in 1915–16. These figures accord well with our general statistics.

It is very difficult to draw general conclusions from such averages. Thus the budgets give no information regarding the use of alcoholic drinks, and although these beverages are not primarily drunk because of their food value, they must be allowed to contribute to the calorific properties of a diet containing them.† Another difficulty is that we have no classification of the families (in the Board of Trade returns) into occupations, while the Rowntree families are not so arranged as to give us an insight into the nature of the work done. Still, making all these reserves, it does not appear that the pre-war statistics demonstrate any necessity for the average working man to consume a diet equivalent to more than 3,500 calories. We can hardly suppose that the manual toil of all the Board of Trade's families below the income level of 30s. was less than moderate; the severity of muscular work does not rise with income—it more often falls. Nevertheless, when we consider the heavy incidence of disease upon the poorer classes and remember that the power to resist almost all infectious diseases is lessened by under-feeding, we shall do well not to build much upon the statistics.

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\* *Proc. Roy. Soc. Edin.*, XXXVII, 1917, Pt. II, p. 117.

† Neumann (*Arch. f. Hygiene*, XLV, p. 37) kept himself in health for months on a diet giving 2,309 calories, 678 of which came from Lager beer. But his work was sedentary, involving little muscular activity.

#### IV. STATISTICS OF WORKING-CLASS DIETS IN WAR-TIME. ENGLISH MUNITIONS WORKERS.

The data we have now to consider were collected during the spring and summer of 1917 in hostels and canteens serving the munition workers in various factories.

A return was made of food purchased for consumption during a specified period, a week or a month. Allowance was made for stock on hand at the beginning and end of the period and the number catered for was determined as accurately as possible.

In a certain number of the establishments, fortunately the most important, the large majority of those catered for received the whole of their nourishment from the food given in the return. But in others it was not so easy to analyse the diets because a larger or smaller proportion of the hostel inmates took some of their meals away from the establishment or, alternatively, some visitors had casual meals out of the food accounted for.

An approximate allowance has been made in the manner now to be described.

Dr. Leonard Hill\* visited a hostel and calculated the average calorie values of each of the four daily meals to be in the following proportions: Breakfast, dinner, tea, supper, as 1,021 : 973 : 603 : 1,097. Roughly, this amounts to allotting to each of the large meals a value of 100 and to a tea a value of 60. That is, dinner, supper and breakfast each provide 100/360 of the day's ration, and tea 60/360 of the day's ration. The "meal value" of a breakfast, a dinner or a supper is therefore  $\cdot 2778$ , and of a tea  $\cdot 1666$ . Using these ratios we can approximate to the daily intake from incomplete data. For instance, in a certain hostel there were 135 tenants and 16 staff. But during the week accounted for 1,057 breakfasts, 1,182 dinners, 382 teas and 412 suppers were supplied. Thus all the 151 inmates had breakfast, but not nearly all had supper or tea, while 125 extra dinners (called trench dinners) were served. The data were treated as follows: The sum of the numbers of breakfasts, dinners and suppers, 2,651, was multiplied by  $\cdot 2778$ , which gives 736.4. The number of teas, 382, was multiplied by  $\cdot 1666$ , giving 63.6. The sum of these products, 800, is the "meal value" of the population.

Dividing the total energy value of the food used, 1,910,000 calories, by 800, we obtain for the daily calories per head the number 2,388, which, as the inmates and staff were all women, must be again divided by 0.8 to reach the "man value" of the diet.

This method assumes that if, for instance, supper is taken away from the hostel its energy value will bear the same proportion to the total energy value of the day's diet as observed *among canteen*

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\* Memo. No. 11, *Health of Munition Workers Committee*.

meals by Dr. Hill. We cannot fully test the validity of this assumption. Dr. Hill (*op. cit.* p. 6) found for three dinners brought by workers (males) from home the values of 683, 1,448 and 1,719 calories; the mean 1,285 does not differ much from that of his canteen observations, but the range is wide.

Among women the range was still greater, from 298 to 1,143 calories. His results suggest that we are not likely to underestimate the energy obtained away from the hostel by the method used, particularly as in the large majority of our instances the meals taken away from the hostel have been obtained in a works canteen. Nevertheless, the method is conjectural, and in our table of results we have marked with a star those establishments in which the "meal value" was much greater than the number of fully boarded residents; such analyses are to be deemed less trustworthy than the remainder.

With this exception the work of analysis did not differ materially from that involved in any statistical reduction of diets. We were frequently perplexed by the diverse local measures of weights and capacity adopted, but usually succeeded in obtaining information on the point.

We often found lacunæ in the returns, which involved our staff in much trouble and correspondence; but here also the difficulties were overcome, and we have reason to think that our results, which cover a larger sample of dietaries than has, so far as we know, ever been compiled for a working-class population observed over a limited period, are as accurate as such data can be expected to be.

The general results are shown in Table 5.

A more detailed analysis showing specific articles is given in Table 6. This refers to L of the general table, and is chosen because the return of quantities here was more detailed than in the majority, and we had special reason to believe that the details were correct.

In considering these figures the circumstances under which the census was made must never be out of mind. The season\* was that of an acute shortage of potatoes, and coincidentally there was an energetic campaign urging the public to "eat less bread." In addition sugar was very scarce. These three factors must combine to diminish the proportion of carbohydrate in any diet, and we should anticipate some change in this direction among hostel returns. We do indeed find a great reduction in the average quota of carbohydrate and, even if we credit the larger part of this to the potato and sugar shortage, the "eat less bread" campaign appears (judging from the bread records) to have had rather more effect upon the hostels, especially the smaller ones tenanted by women, than upon the public in general.

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\* It would be expected that the energy value of the same persons' diets should be more in winter than in summer. On this point we have no adequate statistical information.

The *contre-coup* of this economy has been a remarkable increase in the consumption of fat and an appreciable rise in that of protein. A comparison of the actual weights of protein and fat for the diets of Tables 2, 3, 4 and 5 brings this out, and it is still more apparent in Table 7, which shows the actual and proportional numbers of calories derived from each constituent in the munitions', Rowntree's and Board of Trade's returns. The consumption of fats has almost doubled, while that of the carbohydrates has proportionately declined. The result is that the average energy values have increased in comparison with the worst paid classes before the war. The character of the diet resembles that of the wealthier artisans of Rowntree's second or the servant-keeping members of his third class. It might be said that had the slogan been not "eat less bread" but "eat more fat" the response would have been the same. A sufficiently instructive instance of what happens when the nutritional habits of a population are disturbed by force of circumstances or otherwise is provided by S. Here the bread ration was taken quite literally, and although the 4 lbs. was not, we think, intended to apply to adults, but per head of the whole population, these men were really kept to the 4 lbs. The result was a huge rise in the consumption of fat. The table contains other like instances.

Were these diets sufficient? In one case (O) the inmates specifically complained, and certain recommendations were made to the management.

The second return relating to this hostel (P) shows that the recommendations were acted on with rather excessive zeal. The general average is high, but we do not say that it exceeds the conventional standard.

All the persons catered for were doing active work. At G, N and W the work was hard (although these establishments do not return average diets above the general hostel level). In the remainder it was probably not so hard as that of the metal worker considered in Section II. Also, in view of the large proportion of fat in the diet, the waste between purchase and consumption may have been beyond 10 per cent. Recollection of these facts and possibilities will compel us to be wary in condemning the diets as excessive, or suggesting that there is need here for economy. It is true that this class of the population consumed in the spring and summer of 1917 a diet unlike that of the normal working class, superior to it in popular parlance (which respects rich, *i.e.*, fatty food and meat), but in the face of a potato shortage and appeals to "eat less bread," we do not see what other course was open to the caterers than that they adopted.

Physiologically, we hold that the departure from a normal diet was undesirable because, as we have suggested, there are reasons why carbohydrates should bear the brunt of the struggle to provide energy for work and there are also grounds for believing

that the use of potatoes (*vide supra* p. 15) is desirable. It seems, then, that both our physiological inclinations and economic necessity (in the form of a heavy potato crop and a dearth of fats) point to a radical modification of the dietaries in the direction of reducing the fat and increasing the carbohydrate utilised.

The munitions workers' diets so far considered relate to the spring and summer of 1917, when potatoes were unobtainable. We have now secured some returns covering a period during which potatoes were upon the market. In Table VIIIA we bring together comparable figures for certain hostels investigated during both periods. In Table VIIIB are shown a few hostels for which the summer figures are not available. These latter figures are based upon small numbers and not of much importance.\* It will be seen that so far no great reduction of the meat ration has been practicable, although certain other commodities have been less used. It should be remembered, although the newspaper reader often does not remember, that the existence of large stocks of potatoes in the country is not the same thing as the availability of potatoes in industrial centres. Transport difficulties are now very great in connection with all foodstuffs, especially severe when it is a question of moving large quantities of such bulky articles as potatoes.

## V. THE WAR-TIME DIETARIES OF GERMANS.

We have in the preceding sections given as accurate an account as we can of the diets consumed by handworkers in England before the war and by one class of such workers during the spring and summer of 1917, that is, after nearly three years of war. It will interest the reader if we endeavour to compare home conditions with those of the chief enemy country. So far as pre-war conditions in Germany are concerned, we need say little. The reader has, we hope, already been convinced that theoretical diet scales reflect the prevailing conditions of the country in which they originate.

Hence the German standard dietaries being lower than the American standard we should anticipate that the average German consumption is lower than the American.

A summary comparison of the per caput consumption in various large cities, based on statistics collected by Schiefferdecker and Mayr and reduced by Voit is quoted by Rubner (*op. cit.* p. 206).

According to these returns the average consumption of protein fat and carbohydrates in London was 98 grammes, 60 grammes and 416 grammes, with total energy value 2,661; in Königsburg, 84, 31 and 414, with energy value 2,394; and in Munich, 96, 65 and 492, with energy value 2,903. This comparison, which takes

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\* In two of these hostels, the consumption of food was, in our opinion, excessive, and appropriate official steps were taken.

no account of the man values of the contrasted populations and relates to the experience of many years ago, is not of great value, but it is probably true to say that the normal intake of energy in Germany is about the same as that of Englishmen of the same social and industrial classes.

In a paper by R. O. Neumann (*Arch. f. Hygiene*, XLV, 1902, p. 1) will be found a table embodying most of the dietetic analyses published up to 1902 by European statisticians and physiologists. They are of unequal value and cannot be averaged.

Turning to war conditions, we have consulted the German scientific papers. Few of these—at any rate few of those we have seen—give much information, but an exception should be made in favour of Professor A. Loewy's article, "Ueber Kriegskosten," which was published in the *Deutsche Medizinische Wochenschrift* early in 1917 (issues of February 8th and 15th). Loewy furnished two series of statistics. The former refers to the consumption of food in 858 families, comprising 4,079 individuals, all town dwellers, during April, 1916; the latter to 146 families, containing 644 persons, observed through July, 1916. The analytical values used by Loewy are not the same as those we have employed, but the differences are so distributed among the various articles of consumption that on the average either system leads to the same result (re-calculating one of Loewy's diets with our analytical tables we came to within 1 per cent. of his gross calories).

A much more important difference is the assumed "man" value of the population. Loewy states that he has reckoned children under 11 as each equal to .5 of a man, and all persons aged 11 or more as "men." This cannot be reconciled with his arithmetic.

He states that the April sample consisted of 2,261 adults, 758 children from 11 to 16, 986 children from 1 to 10, and 74 infants. According to his alleged procedure, this would give  $2,261 + 758 + \frac{1}{2}(986 + 74) = 3,549$  "men." He says, however, that he has used 3,733 as divisor. Similarly in the July sample, there were said to be 382 adults, 122 children from 11 to 16, 128 from 1 to 10, and 12 infants, equivalent to 574 "men" by his method; actually his divisor was 601. It is not clear therefore what factors Loewy really did use, but it may be noted that his two divisors give for each population a "man" value of .92 and .93 respectively. The Royal Society's Food Committee computed the man value of the English (1916) population as .77. Hence, to compare the energy results of Loewy's census with our own figures the former ought to be multiplied by  $93/77 = 1.2$ . These corrected figures\* are given in brackets in Table VIII after the original values due to Loewy (or rather the values which Loewy

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\* As Loewy does not state the sex nor classify into the requisite age groups, the direct re-calculations of man values is impossible.

would have obtained had his arithmetic or his proof reader been more accurate).

A comparison of Tables V and VIII brings out some interesting points. The German families were much worse off as regards energy than the munitions workers; they were also worse off than English working-class families before the war.

Loewy comments on his figures in the following terms (*op. cit.* p. 196): "The physiological importance of war limitation of diet is not the same with respect to the protein and the heat equivalents. We have already on the basis of the facts before us adopted the view that an intake of 60–70 grammes of protein is sufficient for requirements. As therefore our war statistics provide a quantum of roughly 68 grammes, we may conclude that this is sufficient except perhaps for very heavy work.

"It is otherwise with the deficit of calories. It must be remembered that the usually accepted value of 2,800 calories errs rather on the side of defect. The circles in which our statistics were collected belong in the majority of instances to the working class where the energy requirements may well amount to 3,000 calories or more. Rubner and his pupils have established that even charwomen\* need 2,500 to 3,200 calories or more, cooks 2,900 to 3,700. The limitation of calories is so serious that the war values could only suffice for a condition of relative rest—that is to say, with exclusion of any strenuous occupational work. Consequently, in the majority of the cases the supply of energy is insufficient and must lead to tissue loss."

What real basis in experimental fact there is for the implications of this passage the reader can judge from our historical summary, but we shall not comment upon it.

Returning to Table VIII, apart from the deficit of total energy as compared with our hostels results, the chief peculiarities are: (1) the large proportion of the energy derived from potatoes, (2) the very small amounts of fat and meat received. The bread ration of 280 grammes a day or 4 lbs. 5 ozs. a week is not widely different from the late Food Controller's voluntary ration (it is to be remembered that owing to Loewy's method of forming a man equivalent, this average is directly comparable with the population per caput value implied in the voluntary ration of bread).

The sugar ration amounted to  $9\frac{1}{2}$  ozs. per week and was above the English standard.

It is unnecessary to analyse the July returns in the same detail. The number of families is smaller and only three income classes are formed: (1) 100 to 200 marks, (2) 200 to 300 marks, (3) 300

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\* The German word "aufwartefrau" is difficult to render. "Charwoman" or "daily girl" come nearest to the sense.

marks or more. The daily calories for each class are 2,249 (2,699), 2,309 (2,771), 2,211 (2,653), so that the total energy values have changed little. Potatoes, however, bulk less largely in the diet, while bread and meat increased. The percentages of energy derived from bread and cereals are 43.2, 42.9 and 38.5, while the potato energy percentages are 15.1, 16.4 and 17.4.

Loewy's paper is the most important we have seen. More recently Berg published (May, 1917, issue of *Zeitschrift des Deutschen Landwirtschaftsrats*) an abstract of certain lectures delivered by him to official bodies. According to his tables, the German army in the year 1916/17 received rations the energy value of which varied from 3,025 to 2,900 calories, the protein content from 99 to 100 grammes, the fat content from 67 to 68 grammes and the carbohydrate quota from 440 to 473.

Labourers on very heavy work received 2,411 calories contained in 66 grammes protein, 34 grammes fat, and 439 grammes carbohydrate. Those on heavy work were given 2,051 calories, from 54 grammes protein, 32 grammes fat and 367 grammes carbohydrate.

Ordinary civilians at Loschwitz, Dresden, actually received only 1,217 calories (33 grammes protein, 9 grammes fat, 140 grammes carbohydrate). Berg does not provide us with sufficient details as to the composition of his Dresden data to enable us to judge the value of his result. *Prima facie* we should consider it to be incredible. The result is said to be an average of 10 weeks, and we do not know either the number or the composition of the families averaged. We do not therefore draw any conclusions from Berg's paper respecting average civilian diets. The official prescriptions of heavy and very heavy workers' diets are of more interest. They, too, are far short of our munitions returns, and, as in Loewy's census, the distribution of energy among the prime constituents is quite different. The bulk of calories is furnished by bread (357 grammes daily for heavy workers with an addition of 100 grammes of wholemeal for the very heavy class), potatoes (429 grammes), fat (30 grammes), turnip cabbage (122 grammes), sugar (26 grammes), and miscellaneous vegetables (145.5 grammes). Only 50 grammes of meat are allowed daily.

Whatever may be said of the total energy value, the allocation of the three constituents approximates more closely to the normal usages of the working classes than do the English hostel diets of 1917.

Summarising this section we believe it to be a fact that the German working man has been decidedly worse off than the English labourer since the war and even since the intensive submarine campaign and increasing world shortage of foodstuffs.\*

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\* Corroborative evidence (not suitable for analysis) is to be found in the articles by Fendler, Stuber and Burger (*Arch. f. Hygiene*, LXXXV, 1916, pp. 1-41 and 199-237).

The extent to which the German civilian population has suffered in health, and therefore efficiency, on account of food shortage is difficult or impossible to determine.

The most trustworthy statistical information available is contained in the Presidential Address delivered before the Royal Statistical Society on November 20th, 1917 by the Registrar-General (Sir Bernard Mallet, K.C.B.). The general infant mortality of Germany has not risen since the war, although it remains much higher than the rate for the United Kingdom. There has been, in comparison with this country, a great increase of civilian deaths at ages over one year in Germany and Austro-Hungary, but the extent to which this is attributable to an admixture of military deaths, which we carefully separate from civil statistics, is unknown. It is, however, significant that in the 1915 figures there is an increase of 123,656 in the deaths due to "violence" over the 1913 returns, while for the first ten months of 1916 such deaths exceed by more than 70,000 the 1913 figure. The Germans have now ceased to publish the figures of violent deaths as a separate item. Under these circumstances the fact that while London has to record an excess of births over deaths from January to August, 1917, the central enemy capitals, Berlin, Munich, Dresden, Vienna, Buda Pest and Prague, all show decreases, varying from 155 per 100,000 living (at Munich) to 1,108 (at Prague), cannot be considered to demonstrate the evil results of short commons.

## VI. THE NEW VOLUNTARY RATION.

In Table IX we give a reduction of the new voluntary ration to man values and show the deficit to be covered on the assumption that the customary standards of energy are to be followed. Even if we assume a weekly per caput consumption of 10 ozs. of dried fish and a daily consumption of 1 pint of milk, both generous allowances, judged from our hostel records, a very large balance of energy remains to be provided from potatoes, amounting to more than 2 lbs. a head daily even for medium workers. The ration actually involves an immense reduction of meat, bringing the population in that particular back to the pre-war standard of the poorer families, without, however, reverting to those families' consumption of cereals. This change will now be effected with greater difficulty than under normal circumstances, the workers having been allowed and encouraged to reduce their consumption of bread and increase their use of meat. Consequently the principle noted above will operate, viz., high protein feeders tend to suffer more inconvenience and loss of efficiency when the diet is reduced than do preponderatingly carbohydrate feeders. This, of course, increases the difficulty of the rationing problem from the administrative point of view. We are not, however, called upon to discuss this difficult subject here.

## VII. GENERAL CONCLUSIONS.

The foregoing pages contain a sufficiently full account of the investigations we have been able to undertake, and we believe that these investigations are worth placing on record.

So far as the munition workers in 1917 were concerned, the picture is not painted in gloomy colours and there is no reason to think that those who have served the nation in munition factories had any reason to complain of the provision made to sustain their physical strength and health. But we cannot shut our eyes to the changes which time will force upon the nation.

The present provision of so many calories from fat and meat as could be made six months ago is no longer feasible. Fortunately, economic necessity and the teaching of physiology, however tentative the latter may be, do seem to point in the same direction. The substitution of energy derived from potatoes and cereals for a large proportion of that yielded by fats and animal proteins would be a change that cannot scientifically be condemned. We do not mean that it would not involve hardship. That a diet such as shown in the 1917 returns is more appetising and *in popular belief*, which counts for much, more "strengthening" are propositions we are in no way concerned to deny. But we can find no evidence that these predilections are rooted in any functional or structural property of the human organism. In this matter of opinion we think that social habit, the desire of the less wealthy to imitate the customs of the more wealthy, has greater weight than physiological demands. This is the real case for rigorous economy and simplicity of diet among the wealthy. Such economy does not sensibly increase the available supply of food for the hand workers, but it sets a conspicuous and good example.

Whether, apart from substitution, actual reduction of the calorie value of diets is a desirable or practicable process is a question we shall not here discuss.

In conclusion, we desire to express our heartiest thanks to the various members of our staffs, especially Miss Lyne, Miss C. M. Thompson and Miss Chrystal, who have been indefatigable in compiling and analysing data, a task the severity of which the reader can hardly realise. We are further indebted to Miss Chrystal for the practical account of difficulties in hostel catering which forms Appendix III of this report.

TABLE I.

*Heat Production and Work.*

Observations of Benedict and Cathcart on M.A.M. pedalling at the rate of 68/72 revolutions per minute.

Work done (calories).	Observed heat production (calories).	Mean of observations.	Heat production given by formula. Heat = 3.3415 multiplied by thermal equivalent of the work + 2.4131
0.47	4.01, 4.01	4.01	3.98
0.48	3.86, 3.88, 3.83, 4.13, 3.96	3.93	4.02
0.49	4.15, 3.94	4.05	4.05
1.19	6.73	6.73	6.39
1.20	6.65, 6.81	6.73	6.42
1.33	6.95	6.95	6.86
1.35	6.97	6.97	6.92
1.36	7.08	7.08	6.96
1.56	7.44, 7.66	7.55	7.62
1.57	7.87, 7.59, 7.53, 7.64, 7.41, 7.51, 7.55	7.59	7.66
1.59	7.56	7.56	7.73

TABLE II.

*Rowntree. Family Budgets. Wages less than 26s.*

	Weekly wages.	Grammes per head daily.			Calories daily.	Cereal ratio.	Per head weekly.			Man value.
		Protein.	Fat.	Carbohydrate.			Meat.	Flour.	Sugar.	
							lbsozs.	lbs ozs.	lbs ozs.	
Class I—										
No. IA	15/-	66.1	80.0	390.0	2614	53.4	1 9	5 13	1 15	4.2
„ IB	15/-	82.0	83.5	438.6	2911	58.4	1 13	6 11	1 5	4.2
„ IC	15/-	70.3	68.4	388.0	2515	59.7	1 3	6 5	0 13	5.0
„ II	22/-	82.6	67.4	479.3	2931	55.3	2 2	6 9	1 4	3.2
„ III	15/-	97.2	71.7	500.3	3117	50.8	1 4	5 0	1 7	2.8
„ IV	15/-	85.4	69.9	529.4	3171	56.6	1 6	7 4	2 1	2.9
„ V	20/-	66.7	72.9	404.8	2611	51.3	1 12	5 11	1 1	3.7
„ VI	11/9	79.3	66.8	461.2	2837	54.6	2 3	6 9	1 4	1.6
„ VII	20/-	88.7	125.9	561.2	3835	50.8	2 8	8 1	1 9	2.6
„ VIII	25/-	65.5	92.4	294.3	2335	37.6	2 14	3 12	0 15	3.2
„ IX	18/-	77.6	109.1	354.1	2785	34.2	2 10	4 1	0 15	2.1
„ X	25/-	92.3	69.4	659.0	3726	53.7	1 9	8 8	2 2	3.3
„ XI	24/-	106.3	152.0	475.3	3798	37.7	5 15	6 1	1 12	2.3
„ XII	21/-	83.5	102.2	469.6	3218	46.3	2 0	6 3	1 5	3.4
„ XIII	22/-	76.8	98.8	302.5	2474	34.8	3 3	3 3	0 15	2.2
„ XIV	19/-	89.7	78.9	492.5	3121	54.9	2 0	7 4	1 6	2.9
Average	18/11	81.9	88.1	450.0	3000	49.4	2 4	6 1	1 5	3.1

TABLE III.  
*Rowntree. Family Budgets. Classes II and III.*

	Weekly wages.	Grammes per head daily.			Calo-ries daily.	Cereal ratio.	Per head weekly.			Man value.
		Pro-tein.	Fat.	Car-bohy-drates			Meat.	Flour.	Sugar.	
							lbs ozs.	lbs ozs.	lbs ozs.	
Class II—										
No. XV	38 /—	148·9	101·5	849·4	5037	56·9	3 0	11 11	1 11	4·8
„ XVI	27 /—	96·9	164·3	468·8	3847	33·2	4 11	4 13	1 6	2·9
„ XVIII		103·6	123·8	450·0	3421	45·7	2 12	6 6	1 2	3·6
Average —		116·5	129·9	589·4	4102	45·3	3 8	7 10	1 6	3·8
Class III—										
No. XIX	Servant-keeping.	132·3	189·2	557·2	4587	31·4	4 3	5 7	1 5	5·1
„ XX	Do.	98·6	154·8	498·7	3889	24·8	3 11	3 9	2 7	5·7
„ XXI	Do.	118·9	181·1	549·0	4423	38·4	5 3	4 11	1 1	2·6
„ XXII	Do.	115·5	169·2	462·8	3945	24·7	4 8	3 7	1 14	5·4
„ XXIII	Do.	111·3	146·5	537·3	4022	24·5	6 4	3 9	2 10	6·9
„ XXIV	Do.	97·2	125·1	459·1	3444	34·6	2 3	4 0	1 1	3·9
Average —		112·3	161·0	510·7	4052	29·7	4 5	4 2	1 12	4·9

TABLE IV.  
*Board of Trade. Family Budgets.*

	Weekly wages.	Grammes per head daily.			Calo-ries daily.	Cereal ratio.	Per head weekly.			Man value.
		Pro-tein.	Fat.	Car-bohy-drates			Meat.	Flour.	Sugar.	
							lbs ozs.	lbs ozs.	lbs ozs.	
No. I —	Under 25 /—.	85·9	58·6	535·7	3094	61·3	1 9	7 5	1 2	3·4
„ II —	25 /— to 30 /—.	91·8	70·6	564·6	3348	55·2	1 13	7 8	1 5	3·5
„ III —	30 /— to 35 /—.	99·0	82·4	587·6	3581	55·5	2 3	7 9	1 7	3·4
„ IV —	35 /— to 40 /—.	97·8	86·4	581·6	3589	54·0	2 4	7 8	1 8	3·5
„ V —	Over 40 /—.	108·3	100·1	643·5	4013	53·3	2 6	8 4	1 11	4·0

TABLE V.

*Hostels.*

Hostel or canteen.	Numbers catered for.	Grammes per head daily.			Calories daily.	Cereal ratio.	Bread per week.	Report dated.
		Protein.	Fat.	Carbo- hydrates.				
A	2600	110.4	113.3	414.8	3207	48.6	lbs. ozs. 8 4	24.3.17
B	9	101.9	90.9	465.0	3166	56.0	8 4	14.7.17
C*	520	159.1	203.9	791.6	4154	25.2	3 13	26.6.17
D	100	104.9	128.0	366.2	3122	41.8	6 0	28.7.17
E	22	69.1	69.9	295.3	2144	40.1	5 10	14.7.17
F	600	125.8	171.4	350.6	3547	29.5	5 12	21.7.17
G*	4595	98.0	119.4	363.9	3004	33.2	2 8	13.6.17
H	151	125.4	130.9	436.0	3519	28.4	4 4	30.6.17
I	40	117.3	110.3	395.8	3130	36.9	5 0	23.6.17
J	370	95.8	126.8	291.8	2768	41.1	5 0	29.4.17
K	441	115.9	137.0	427.8	3503	46.4	5 10	13.5.17
L	7230	132.7	156.2	476.6	3951	39.7	6 4	30.6.17
M	57	146.0	244.4	386.3	4455	15.8	3 8	30.6.17
N	262	119.2	114.2	462.8	3448	49.3	7 3	15.6.17
O	105	102.1	123.4	283.2	2727	29.7	4 14	13.6.17
P	105	121.5	151.9	528.2	4076	36.6	6 3	11.8.17
Q	370	109.4	138.5	326.5	3075	29.9	4 1	31.8.17
R	42	104.3	139.6	465.0	3632	35.4	4 1	4.9.17
S	35	135.1	214.3	381.9	4113	23.5	4 0	25.8.17
T*	1150	121.0	152.8	395.6	3539	28.3	3 11	30.6.17
V*	46	118.1	151.4	625.1	4455	46.6	9 13	1.9.17
W	363	112.5	121.6	455.6	3460	44.5	7 14	1.9.17
Average		115.7	141.3	408.4	3463	36.7	5 8	

TABLE VI.

*Hostel "L."*

Details of principal articles of consumption.

	Weekly con- sumption per man.	Grammes per man weekly.			Calories per week.
		Protein.	Fat.	Carbo- hydrates.	
	lbs.				
Meat ... ..	3.71	252.28	302.92	—	3,851.50
Bacon ... ..	0.39	16.77	106.16	—	1,056.05
Cooked bacon ... ..	0.30	27.49	30.48	—	396.17
Boned ham ... ..	0.306	19.84	38.17	—	436.33
Sausage ... ..	0.390	22.97	78.16	1.94	829.02
Kippers ... ..	0.170	15.81	6.79	—	127.97
Fresh fish ... ..	0.190	8.63	0.86	—	43.38
Dried fish ... ..	0.410	36.45	9.92	—	241.70
Tinned salmon ... ..	0.09	7.96	3.06	—	61.09
Milk ... ..	6.2088	95.62	112.38	140.94	2,015.03
Margarine ... ..	0.62	3.37	236.28	—	2,211.22
Cheese ... ..	0.230	26.08	31.28	2.60	408.49
Bread ... ..	6.26	227.18	33.80	1,490.51	7,356.87
Flour ... ..	0.36	18.78	1.64	122.47	594.38
Oatmeal ... ..	0.245	17.89	8.01	75.02	455.42
Rice ... ..	0.23	8.35	0.31	82.41	375.00
Cake ... ..	0.170	4.62	6.94	50.12	288.98
Scones and buns ... ..	0.300	9.16	10.39	78.78	457.18
Biscuits ... ..	0.62	27.97	2.77	237.43	1,113.90
Sugar ... ..	1.012	—	—	449.83	1,844.30
Jam ... ..	0.80	2.16	0.36	180.80	753.48
Green peas ... ..	0.29	4.72	0.26	12.85	74.46
Rhubarb ... ..	0.50	0.91	0.91	4.99	32.65
Tea ... ..	0.32	—	—	—	—
Totals ... ..		855.01	1,021.85	2,930.69	25,024.57
Daily averages ... ..		122.14	145.98	418.67	3,574.94

*Note.*—The difference between the above averages and the entries on Tables V and VII is due to the inclusion in the latter of the nutritive constituents of a large number of smaller items (eggs, dried fruits, poultry, &c.) which were not consumed in sufficiently large quantities per head for their detailed tabulation to be useful.

TABLE VII.

*Energy Equivalent of Various Dietaries.*

	Protein.		Fat.		Carbohydrates.		Total calories.
	Calories.	Per cent.	Calories.	Per cent.	Calories.	Per cent.	
Rowntree—							
Class I ...	335.79	11.2	819.33	27.3	1,845.0	61.5	3,000
Class II ...	477.65	11.6	1,208.07	29.5	2,416.54	58.9	4,102
Class III ...	460.43	11.4	1,497.3	36.95	2,093.87	51.68	4,052
Board of Trade—							
Class I ...	352.19	11.4	544.98	17.6	2,196.37	71.0	3,094
Class II ...	376.38	11.2	656.58	19.6	2,314.86	69.2	3,348
Class III ...	405.90	11.3	766.32	21.4	2,409.16	67.3	3,581
Class IV ...	400.98	11.2	803.52	22.4	2,384.56	66.4	3,589
Class V ...	444.03	11.1	930.93	23.2	2,638.35	65.7	4,013
All munition makers ...	474.37	13.7	1,314.09	37.9	1,674.44	48.4	3,463
Hostel " L " ...	544.07	13.8	1,452.66	36.8	1,954.06	49.5	3,951

TABLE VIII.

*German Diets, April, 1916 (Loewy).*

Monthly income in marks.	100-200 (319 families).	200-300 (271 families).	300-400 (139 families).	400-500 (37 families).	Over 500 (32 families).
Daily calories ...	2,367 (2,840)	2,279 (2,735)	2,326 (2,791)	2,264 (2,717)	2,563 (3,076)
Daily protein (grammes) ...	67.1 (80.5)	66.6 (79.9)	68.6 (82.3)	69.4 (83.3)	78.5 (94.2)
Daily fat (grammes) ...	28.8 (34.6)	28.4 (34.1)	29.5 (35.4)	27.3 (32.8)	30.0 (36.0)
Daily bread (grammes) ...	285.8 (343.0)	278.1 (333.7)	265.9 (319.1)	260.0 (312.0)	262.5 (315.0)
Daily meat and sausage (grammes) ...	40.3 (48.4)	48.0 (57.6)	59.8 (71.8)	68.2 (81.8)	74.9 (89.9)
Daily potatoes (grammes) ...	606.9 (728.3)	546.6 (655.9)	563.9 (676.7)	478.3 (573.9)	502.3 (602.8)
Daily sugar (grammes) ...	40.6 (48.7)	38.0 (45.6)	37.8 (45.4)	39.5 (47.4)	43.5 (52.2)
Percentage of total energy derived from bread and cereals ...	38.1	38.7	37.0	38.4	34.5
Percentage of total energy derived from potatoes ...	22.9	21.6	21.8	19.0	17.6

TABLE VIIIA.

*Hostel Food Values. Comparative Table. Six Hostels.*

Hostel	Report dated.	Grammes per head daily.			Calories daily.	Cereal ratio.	Pounds per head weekly.			
		Pro-tein.	Fat.	Car-bohy-drates.			Meat.	Bread	Pota-toes.	Sugar.
A 1	24.3.17	110.4	113.3	414.8	3,207	48.6	5.09	7.58	—	1.08
A 2	28.10.17	124.0	116.9	446.5	3,426	40.4	4.74	7.14	4.84	0.41
D 1	28.7.17	104.9	128.0	366.2	3,122	48.1	4.42	6.0	2.81	0.50
D 2	28.10.17	101.9	118.8	420.8	3,248	35.0	3.26	4.14	5.80	0.59
H 1	30.6.17	125.4	130.9	436.0	3,519	28.4	4.79	4.20	—	1.23
H 2	28.10.17	131.0	128.3	485.8	3,721	32.1	5.63	4.94	6.59	0.99
J 1	29.4.17	95.8	126.8	291.8	2,768	29.9	5.65	4.96	0.75	0.33
J 2	31.8.17	109.8	138.5	326.5	3,077	29.8	5.18	4.09	2.99	0.89
J 3	28.10.17	148.4	196.8	492.9	4,459	28.1	7.46	6.13	7.83	0.41
K 1	13.5.17	115.9	137.0	427.8	3,503	46.4	5.55	7.66	—	0.94
K 2	28.10.17	128.8	121.6	450.0	3,504	43.2	4.84	5.94	3.27	0.31
X 1	9.6.17	—	—	—	3,189	34.4	4.94	5.94	—	1.16
X 2	28.10.17	115.4	112.0	546.9	3,757	47.2	4.12	9.53	5.28	0.55

TABLE VIIIB.

*Hostels.*

Hostel	Num-bers ca-tered for.	Report dated.	Grammes per head daily.			Calo-ries daily.	Cereal ratio.	Pounds per head weekly.			
			Pro-tein.	Fat.	Car-bohy-drates.			Meat.	Bread	Pota-toes.	Sugar.
I	21	22.9.17	144.0	187.1	595.3	4771	49.0	3.03	11.05	0.79	0.59
II	32	20.10.17	94.3	111.1	316.4	2717	34.3	4.26	3.34	5.19	0.93
III	59	3.11.17	120.1	108.3	570.9	3840	54.7	2.86	11.90	3.75	0.75
IV	20	27.10.17	106.5	85.8	636.0	3840	64.0	1.80	10.50	3.50	0.44
V	12	3.11.17	88.3	132.1	429.0	3349	37.3	2.60	4.50	3.50	0.75
VI	42	3.11.17	89.4	87.4	472.5	3117	51.0	2.06	8.44	4.38	0.78
VII	36	15.9.17	153.9	168.8	655.8	4889	49.0	5.11	10.75	—	1.25

TABLE IX.  
*Energy Value of Voluntary Ration.*

	Bread per head.	Grammes per head daily.			Calories daily.	Cereal ratio.	Calories re- quired.	Deficit.
		Pro- tein.	Fat.	Car- bohy- drates.				
MEN—	lbs.							
Heavy work ...	8.0	66.9	64.3	340.2	2,268	67.1	4,000	1,732
Medium work	7.0	61.7	63.5	306.3	2,099	64.4	3,500	1,401
Sedentary work	4.5	48.7	61.6	221.3	1,680	55.5	3,000	1,320
WOMEN—		Man values.						
Heavy work ...	6.25	64.3	77.5	297.9	2,205	57.6	4,000	1,795
Medium work	5.0	57.8	76.5	255.4	1,995	53.2	3,500	1,505
Sedentary work	4.375	54.5	76.0	234.1	1,890	50.6	3,000	1,110

## APPENDIX I.

## NOTE ON THE SCIENTIFIC STUDY OF BIO-ENERGETICS.

We stated in the text that to measure the energy requirements of the human machine in the way that engineers calculate the precise needs of inanimate machines was a method not as yet sufficiently standardised to provide a simple basis for rationing. It may interest the reader if we explain briefly the actual position.

*Resting Metabolism.*

The output of 1 calorie per kilo of body weight and hour, given in the text, is based upon a large number of concordant observations and appears to be true for quite wide ranges of body mass. Thus, it held for Benedict and Cathcart's cycling subject who weighed 65.9 kilos (without clothes) and one of us, using the Zuntz method, obtained a but slightly higher figure for his own "resting" metabolism, although his body mass was a great deal smaller (1.10 cals. per kilo and hour, the body mass being 46.6 kilos). It is theoretically impossible that the true relation between heat, loss and body mass can be linear, as this formula would imply, because the heat loss is a function not of mass but of surface, and consequently not linear with respect to mass. The reason why the linear relation *appears* to hold is that within fairly wide ranges of mass, the true functional relation is *approximately* represented by a linear formula, precisely as within certain ranges the relation between a number and its logarithm is represented with sufficient accuracy for ordinary purposes by a straight line. The range seems to be wider than might have been expected, another illustration being that a set of data due to Amar and relating to the work performance of 37 Arab labourers\* is also described with sufficient accuracy by an expression of the form  $H = aW + bM + c$ ,  $H$  being heat production,  $W$  external work (both measured in calories),  $M$  the body mass (in kilos),  $a$ ,  $b$ ,  $c$ , numerical constants.

*Efficiency of Work Performance.*

There are two difficulties involved in the study of this subject. The first is that the great majority of modern exact experiments have reference to a single type of external work, viz., pedalling a stationary bicycle against a known resistance (*e.g.*, the experiments of Atwater, Benedict and Cathcart, Amar and Macdonald); it is true that other kinds of work have been studied quantitatively (notably by Chauveau), but the resulting material is not very extensive from the statistical point of view, and the measurements of work performance are open to criticism. The reason of the choice of a bicycle has been the comparative ease with which exact measurements of work performance can be made upon this kind of ergometer. The obvious objection is that what is true of cycling need not be true of the muscular activities involved in other employments. This objection cannot be met until an equally precise and numerous series of experiments has been carried out on other ergometers, and there are serious technical difficulties in the way of such experiments. One may be mentioned, that of *negative* work. If experiments are made upon, for instance, a man raising his body against gravity a certain distance, allowance must be made for the fact that when he descends again, although as a useful machine he should be doing no work as a living machine he *is* doing work, for the muscles are checking the tendency to drop like a stone (*travail résistant*); the numerical measure of this resisting work can only be deduced from the amount of energy metabolised, *if the efficiency of trans-*

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\* *Le Rendement de la Machine humaine*, Paris, 1910.

formation is known, which is precisely what we desire to measure. No really satisfactory plan of overcoming the difficulty has been devised. Of course, a bicycle ergometer does not cause this inconvenience at all.

The second main difficulty, unlike the one just mentioned which can hardly be overcome, is a mere matter of terminology. Different writers have used different definitions of efficiency. Some take as the *gross efficiency* the ratio of the heat equivalent of the work performed to the total energy transformation of the worker, *i.e.*,  $W/H$ . Others (the majority) prefer a *net efficiency* obtained by subtracting from the denominator of the above fraction the resting metabolism of the subject, *i.e.*, they take  $W/(H - h)$ . But there is no general agreement as to what should be taken for the "resting" metabolism ( $h$ ), whether it ought to be that of a man in bed, or of a man sitting on the ergometer without rotating the pedals, or rotating them with no load, &c. Further, this definition, or that of gross efficiency, may lead to equivocal deductions. For instance, suppose the heat production for persons of constant weight to be represented by a simple equation,  $H = aW + c$  (which is approximately true for work on a bicycle ergometer), then the relation between increments of work and heat is constant, each increase of a work unit will involve an increase of  $a$  units of heat production. But neither gross nor net efficiency will be constant, both will increase with  $W$ , because  $\frac{W}{aW + c}$  will only become equal to  $1/a$  when  $W$  is infinite. From this we are not entitled to infer, as some have inferred, that the human machine works more economically the greater the amount of work to be performed, without some risk of misunderstanding; the economy is a necessary consequence of the measure used. To avoid this inconvenience, it is perhaps best to restrict the term efficiency to mean incremental efficiency, which we define as  $dW/dH$  (or, as it usually is more convenient to express  $H$  as a function of  $W$ , as  $1/dH/dW$ ).

Now a scrutiny of the data amassed by Benedict and Cathcart (which are confirmed by the equally careful but less extensive data of Macdonald) leads to the conclusion that for the range of work performance studied,  $H = aW + b$ , where  $a$  is a constant and  $b$  a variable parameter. The variable parameter  $b$  depends (we are here supposing the measurements to be made on one subject so that body mass is constant throughout) on the rate at which the work is done. For instance, with Cathcart and Benedict's subject,  $a$  was 3.3 when the pedals were rotated at 68 to 72 times a minute, 3.6 when they were rotated at 98 to 103, 3.1 for 103 to 107, 3.3 for 108 to 112; *i.e.*, no regular change. On the other hand, the values of  $b$  for these speeds were 2.4, 3.8, 5.15 and 5.20, *i.e.*, a considerable increase with speed. This amounts to saying that, although the *efficiency*, the incremental efficiency as above defined, is constant, *the total cost of work* increases with speed of performance. Theoretically, this result raises the very interesting point, whether cost of work can, as Macdonald\* holds, be divided into two distinct fractions, each of which needs separate consideration and arises in a different way from the other. This is, however, a question which cannot be settled without further research, because our range of observations begins at a point corresponding to a quite considerable amount of external work (in Benedict and Cathcart's series the data from which the above equation has been deduced comprise no values of  $W$  less than .48 calories, say, 204 kilogramme-metres, per minute, which is tolerably strenuous work); hence, it is an assumption to say that the linear law is valid for all values of  $W$  down to and including  $W = 0$ , with the corollary that  $b$ , which is much greater than the resting output of the subject, measures the cost of putting the machine into train to do work, its "bracing up," so to speak. On these grounds the practical application of efficiency measurements is to be made with caution.

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\* *Proc. Roy. Soc., B.*, 1917, LXXXIX, 394.

### *Influence of External Conditions.*

The very great effect of external conditions upon the rate of heat loss from the body has been dwelt upon by numerous physiologists, the work of Lefèvre\* and the more recent experiments and observations of Leonard Hill† being especially noteworthy. In general the problem, so far as industrial conditions are concerned, has been to secure ventilation adequate to protect the body when strenuously working from becoming overheated. The other side of the question must, however, be noticed, viz., that light work carried out either by choice or through necessity, under conditions favouring rapid loss of heat, will involve a transformation of energy in excess of the normal requirements of the work itself. It is impracticable to give any directly relevant figures for industrial work, but the following illustrate the point. Hill investigated the metabolism of eight persons who sat quiet for successive half hours, first in a room and then on the roof of a London building (*op. cit.* p. 36) exposed to cold wintry weather. Analysing his data by the Zuntz Schumburg method, we find that the mean heat production per minute was 1·32 calories. Resting outdoors it was 2·00, an increase of more than 50 per cent.

## APPENDIX II.

### SUMMARY OF STATISTICAL EVIDENCE RESPECTING WORKING-CLASS DIETARIES.

For the sake of completeness we give here further information derived from published data which have not been specially mentioned in the text of the report.

#### *British Agricultural Labourers.*

The Fiscal Blue Book (Cd. 1761, Board of Trade, 1903) provides estimates of consumption furnished by rather more than 100 inquirers in different parts of England. Reducing their data on the assumptions made for the analysis of the Board of Trade's industrial returns, we have the following results :—

	Protein (grammes).	Fat (grammes).	Carbo- hydrates (grammes).	Calories.
Northern Counties ...	88·1	113·1	546·6	3,654
Midland Counties ...	87·6	89·9	537·3	3,398
Eastern Counties ...	92·4	82·9	597·0	3,598
Southern and South- western Counties	95·7	83·9	600·3	3,634

#### *Belgian and American Industrial Workers.*

The data respecting Belgian labourers were collected by Slosse and Waxweiler of the Solvay Institute‡, those for American operatives are due to the investigators of the Nutrition Department (American Department of Agriculture). The "man" values were reached by the method of Atwater. The mean values for protein, fat, carbohydrates and calories do not refer

\* *Chaleur animale et Bioenergetique*, Paris, 1911.

† Report on Ventilation, &c., L.G.B., *Public Health and Medical Reports*, N.S., No. 100 1914.

‡ *Op. cit.* We take the American figures from Slosse & Waxweiler's summary.

to food as purchased, but to *food absorbed*. That is to say, allowance has been made by the investigators for the differences between the coefficients of absorption of different substances and their waste in preparation, while the energy values appropriate to the combustion of proximate principles actually absorbed have been used. Consequently, the values should be increased to make them comparable with the other data. The figures in brackets in the following tables are the calorie values of the diets, as purchased, determined on the assumption of 12 per cent. loss between purchase and absorption. Slosse and Waxweiler classified their subjects into men on moderate, hard, and very hard work. This classification is, however, somewhat arbitrary, which may explain the fact that the energy value of the hard work diets was actually inferior to that for moderate work. The authors did not provide general means, and some of the individual data suggest printers' errors or slips in computation. We have gone through the individual figures and, grouping moderate and hard workers together, reach the following results.

Group.	Number of records.	Protein (grammes).	Fat (grammes).	Carbo-hydrates (grammes).	Calories.
Moderate and hard	687	83.4	98.3	524.3	3,495 (3,972)
Very hard ... ..	372	84.3	113.1	562.8	3,772 (4,286)

These authors have also collected those American data which were derived from industrial labourers. Classifying them on Slosse and Waxweiler's system, omitting orientals and negroes, we find :—

Group.	Number of records.	Protein (grammes)	Fat (grammes)	Carbo-hydrates (grammes).	Calories.
Moderate and hard	155	117.1	162.2	433.8	3,869 (4,397)
Very hard ... ..	199	139.4	228.7	569.6	4,735 (5,381)

As stated, the industrial classification is somewhat arbitrary ; we have therefore formed other classes, which certainly represent different amounts of muscular work. The groups chosen are printers, weavers, miners and quarry workers (Belgian data).

The results are as follows :—

Group.	Number of records.	Protein (grammes).	Fat (grammes).	Carbo-hydrates (grammes).	Calories.
Weavers ... ..	156	80.6	86.9	529.4	3,366 (3,825)
Printers ... ..	36	94.9	102.8	586.4	3,817 (4,337)
Miners ... ..	115	77.2	126.7	496.6	3,604 (4,095)
Quarry workers ...	49	86.2	129.6	657.8	4,314 (4,902)

So far as protein intake is concerned, the Belgian operatives were less liberally supplied on the whole than the English or, *a fortiori*, the American families, but there is no deficit of energy. These extensive data support the conclusion tentatively adopted in the text that an energy value of 3,500 calories in food as purchased is a lower limit of the requirements of industrial workers engaged on moderately strenuous tasks. An interesting point is the higher consumption of the printers, although their occupation is on the whole less exhausting than that of weavers. A probable factor is the high external temperature at which work is done in some weaving sheds; economic conditions (rates of earnings) may also be involved. An apparent paradox in the data is the low energy value of agricultural labourers' diets compared with those of industrial workers. Speed of work performance may have something to do with this. As pointed out in Appendix I, speed makes a great difference to the energetic cost of work as a whole, and the rate of performance is much more at the individual's choice in agricultural work than when the determining influence is the speed of machine drive. It is also arguable that the English agricultural labourers were under-nourished in consequence of their low earnings. A few budgets of agricultural consumption collected by us since the war, with its attendant rise of labourers' earnings, show a higher average of energy intake, but the number of observations is insufficient to support an argument.

The data, as a whole, appear to us to show that working-class consumption in this country since the war has not changed, so far as total energy value is concerned, and is not extravagantly high in comparison with that of other working class populations. This is a conclusion of some importance, and depends upon a really considerable bulk of evidence. We do not think therefore that the charges brought by some against the working classes of having yielded to the temptation to consume more food than is necessary under the stimulus of high wages have any wide basis of fact.

A matter of great practical interest in the statistical reduction of diets is the accuracy of the coefficients of reduction to "man value" for a mixed population which, following the example of the Royal Society (Food Committee), we have adopted from Atwater. Slosse and Waxweiler justly remark that there is room for considerable difference of opinion respecting the validity of these coefficients, and they were able to perform some—unfortunately, only a few—control experiments, the quantities of food received by each member of the household being weighed separately. In one family, consisting of a man, wife, two children aged 9 and 7 years, the *observed* man value was 3.23, the Atwater value being 2.8. In a second family (man, wife, child of 9) the observed value was 2.55, the Atwater value 2.3. In a third family, consisting of father, mother, two children aged 7 and 6, two adult female servants, the observed value was 4.95 as compared with a theoretical 4.4. A longer series of observations (five periods of six days) upon a man and his wife gave 1.87, the theoretical value being 1.8.

These experiments are not numerous enough to lead to very definite conclusions, but they suggest the following reflections:—

(1) The reduction of adult females to adult males by the factor .8 is sufficiently exact. Thus, the observed values in Slosse and Waxweiler's series were .93, .80, .86, .94, .71, .87, with a mean of .85.

(2) For children and adolescents the Atwater coefficients are probably too low, *perhaps* a great deal too low. Observed values, each of which should be on Atwater's basis .5, are .7, .6, .75, .7, .74, with a mean of .70, a considerable discrepancy.

The bearing that these results have upon our work is to suggest that while our munitions hostels data (which are concerned only with adults) are satisfactorily reduced, the other data, which depend upon family budgets, over-estimate, when thus reduced, the "man" consumption.

For instance, take the normal family of man, wife and four children, of the Board of Trade's agricultural budgets, to which we have given a man value of  $1 + .8 + 4 \times .51 = 3.84$ . Taking the factor for children as .7 instead of .51, the man value becomes 4.6, and the *per caput* man consumption is reduced to 83.5 per cent. of its tabulated value. On this assumption the calories for Belgian industrial workers comparable with the munitions' means would be not 3,972 and 4,286 but 3,317 and 3,579. It would, however, be unwise to put much emphasis upon a small sample of controls, although the difficulty is an important one.

### APPENDIX III.

#### FOOD IN HOSTELS.

By Miss E. M. Chrystal (Welfare and Health Section,  
Ministry of Munitions).

##### *Quantity.*

The theory of food in hostels is that the amount given should be sufficient to provide the energy necessary for the work which has to be done by the residents and to maintain their body weights. The amount of energy which is required for munition work has been studied and the quantities of food thought necessary published in Memorandum No. 11\* of the Health of Munition Workers' Committee. The results are given in the form of calories or energy values which measure—

1. The energy expended in mechanical work (1 calorie being equivalent to the energy expended in lifting 1 kilogramme through 425.5 metres); and
2. The energy value of foodstuffs.

From these two results the calorie values of the food required by men and women engaged on munition work are found. For a man on moderate munition work, 3,000 to 3,500 calories per day were fixed as a standard, the corresponding figure for women being 2,400 to 2,800 calories.

The foodstuffs which provide for the repair and growth of the body and which replace the energy expended in work are divided into three classes, protein, fat and carbohydrates, and a standard of proportion of the three in the diet widely used was protein 100 grammes, fat 100 grammes, carbohydrate 400 grammes.

If a hostel matron were to use these results to calculate her tenants' diet she would take as her standard for the three main articles of food, viz., meat, bread and margarine, the following:—

- 1 lb. beef gives 1,039 calories. (Contains 68 grammes protein, 82 grammes fat.)
- 1 lb. margarine gives 3,566 calories. (Contains 5 grammes protein, 381 grammes fat.)
- 1 lb. bread gives 1,176 calories. (Contains 36 grammes protein, 5 grammes fat, 239 grammes carbohydrate.)

She would aim at providing for women breakfast, dinner and supper, giving energy value of about 800 calories each, and tea giving about 500 calories, and she would also try to obtain a good distribution of the three classes of foodstuffs amongst the food she gives.

The food given in hostels is actually tested by the above standards. Matrons are asked to make a return of amounts of food bought during one week, on a special form drawn up by the Ministry. These returns are analysed.

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\* And subsequently No. 19.

Food forms have been sent to 186 hostel units\* and 158 of those completed have been investigated with the following results :—

No. of hostels which reach the standard.	No. of hostels in which the calorie value is above the standard.	No. of hostels in which the calorie value falls below the standard.
38	110 (109 of which are under one management)	10

*Note.*—Allowance is made for meals taken away from the hostel.

In two cases among the number of hostels falling below the standard the cereal ratio was deficient. In the group of 109 in which the calorie value was found to be above the standard, the proportion of fats was excessive.

In practice matrons of small hostels do not calculate their tenants' diets on a scientific basis, as shown above, but allot the quantities according to custom or cost per head.

The following amounts are given in hostels which have been tested and found satisfactory.

Women	{	Meat ... ..	3½ ozs. to 8 ozs. per head per day.		
		Bread ... ..	3 lbs. to 6½ lbs.	„	„
		Margarine ...	4 ozs. to 8½ ozs.	„	„
Men ...	{	Meat ... ..	6½ ozs. to 12 ozs.	„	„
		Bread ... ..	6 lbs. to 7 lbs.	„	„
		Margarine ...	4½ ozs. to 8½ ozs.	„	„

In hostels specially meant for munition workers more liberal helpings are given than in those which were started for women on lighter work, *e.g.*, shops, and have taken in munition workers for the war. This is largely a question of cost as the charges were fixed for tenants who were earning lower wages, and have not been raised to the level of those made in munition hostels. On the whole, matrons have sound views on the necessity of giving liberal quantities to women engaged on heavy work.

#### *Quality.*

As the result of investigations made personally by the inspectors, it has been found that on the whole the meals provided are of good quality. Occasional toughness of the meat has been observed, but, so far as is known, little indigestion has been traced to this cause. Various points which have been noted about methods of cooking in the above connection will be referred to later on.

#### *Variety.*

Variety affects efficiency both physically in relation to digestion and psychologically. Sameness is apt to characterise institutional food, and it is not surprising that hostel catering should have the same fault. Detailed observation has led inspectors to believe that one of the secrets of successful hostel management lies in preserving the tenants' interest in their meals. It is a common experience in hostels that the nerve strain of heavy munition work produces in women a disposition to be difficult about food, and where there is little discontent it is generally found that variety of food is studied. The great difficulty is that, although monotony is resented, the workers are conservative and suspect new dishes. In small hostels there is not much margin for experimenting. The solution of the problem seems to be to include regularly in the menu the dishes which are popular in the district and to vary the rest as much as possible.

\* The data are analysed in the text; the unit here used is an administrative one, several such units are grouped together in the text of the report.

*Meals Provided.*

The number of meals given in the hostels varies from two to four. Four are given when the works are near enough for the residents to return home during the intervals.

The types of meals provided are as follows :—

- Breakfast.* Porridge (in some parts of the country) ; some meat dish, *e.g.*, fish, bacon, sausages ; tea, bread and margarine, jam.
- Dinner.* Meat, two vegetables, pudding or stewed fruit. A cup of tea is sometimes given. In some hostels, mostly the poorer ones, meatless days are observed. In Roman Catholic hostels residents are invariably dispensed from the Friday abstinence, owing to the scarcity of fish.
- Tea.* Bread and margarine, jam, cake, tea.
- Supper.* Cold meat or a made-up dish ; a milk pudding, bread and cheese, tea, coffee or cocoa.

The intervals between the hostel meals average from five to six hours, but workers nearly always have something to eat during that period at the works. Very long intervals are inquired into by the inspectors.

*Food Provided and Methods of Cooking.*

Staple dishes of districts have been referred to above. The importance of providing these lies in the fact that the digestive organs can utilise more easily food to which they are accustomed. Among such dishes the following have been noted.

*England.* In the southern Midlands and the south the kind of food which is popular is heavier than that which is customary in the north. More meat is eaten on the whole, and suet puddings and rolls are included more frequently.

*In the north of England and Scotland* more porridge is eaten. In many Scottish hostels no meat dish is provided at breakfast in addition to porridge.

Fried fish and chips are favoured by many Yorkshire and Scottish workers in preference to meat. Meat turnovers and shepherd's pie, broth and boiled beef are popular Scottish dishes also. In general, meat is not considered so indispensable by Scottish working people as it is in England. This applies especially to women.

For tea and breakfast oatcake and barley meal scones are eaten in the north. Substitution has been more successfully carried out in baking materials in the north than in the south, this result being probably due to traditional skill.

These characteristic differences between north and south are seen best in the small hostels. They become lost in large munition centres where hostel residents come from all parts, *e.g.*, Gretna, and the problem of catering is correspondingly complicated. Variety is again the solution. Different forms of stews are found useful, especially those in which vegetables are mixed. These are best cooked and served in French casseroles, which have two virtues :—

1. They preserve all the flavour of the stew.
2. They can be brought to the table, and the waste of time and cooling of the food involved in dishing the stew is avoided.

Potato dishes are being tried with considerable success. Maize has been found to be unpopular and indigestible. Suet puddings and rolls are thought by the workers to be sustaining. Meat pasties are also

popular. These and cottage pies are economical of meat, but it has been found best to make them of fresh meat and not from what is left over from the day before.

*Provision of lunches to be taken to the factory* is a difficult matter. Carried food is bound to be unsatisfactory for two reasons :—

1. It becomes dry and unpalatable if in the form of sandwiches.
2. If it is in a made-up form its digestibility is certain to suffer in the process of re-heating.

It is not, however, possible to abolish the system entirely. It is much cheaper for girls to pay an inclusive fee and take lunch from the hostel. There is a strong prejudice especially in the north in favour of bringing food to work rather than buying it at the canteen. In many small works there is no canteen, only a mess-room.

The following lunch, provided at a hostel where catering is satisfactory, gives an idea of what is necessary :—

- 1 slice of meat roll (made with very little meat and strongly flavoured with onion).
- 1 square of jam tart.
- 2 rounds of bread and cheese.
- $\frac{1}{2}$  round of bread and butter.
- Dry tea or cocoa.

The system of giving dinner tickets for the factory canteen as part of the board paid for by the girls has been successful in some places and not in others. A suggestion has been made in connection with one of the large national canteens to provide a contract for feeding a worker at so much per week at a cheaper rate than hitherto, and to issue tickets to lodgings keepers and hostel matrons for their tenants. It is hoped that the system may be adopted by the hostels and by workers in lodgings also. When this matter of carried food is put before the girls in hostels, they always agree about the advantage of buying fresh food, but complain of the expense.

### *Methods of Cooking and Serving.*

Three methods of cooking are used, steam, gas and coal range.

Steam cooking is used in large up-to-date hostels, and sometimes in hostels in remote places, where gas is not to be had. Steam can be used in such a case for heating cubicles, drying room and bath water, as well as for cooking.

Gas stoves are used in the majority of hostels because they are convenient and economical. Coal ranges are used in small hostels, particularly in adapted dwelling-houses.

The only remark to be made as to the merits of the three methods is that workers often complain that steam-cooked food is apt to be sodden and tasteless.

*Methods of serving* are important for two reasons :—

1. Food that is meant to be hot must be served hot to ensure digestibility.
2. A good method of serving saves the time of the staff. Owing to the difficulty of getting staff at all, their convenience must be studied in every possible way.

In large hostels specially built for munition workers the service arrangements are simply those of a factory canteen. There are hatches between the service room and dining-room, or an open counter with a hot plate under it. Quick service can be arranged for by securing proper distribution of labour amongst the kitchen staff, so that the girls or men are not kept standing too long in queues.

In houses which have been adapted, arrangements are more difficult.

The simplest plan of all is one which can be adopted in hostels where girls are housed who have not been accustomed to much space at home. It is to make the kitchen the dining room. The range is either screened off or the cooking is done in the back kitchen on a gas stove. In small hostels where the staff is tidy this plan works fairly well, although a visit paid while a meal is going on gives an impression of some confusion. The advantage of the plan is that the girls feel that it is homelike. They like to help with the serving, washing up, &c., as they would do in their own homes. Some staff can be saved in this way. The only hostels which exist of this type are in the north. In one of the poorer parts of Glasgow, in Dundee, and in one or two places in the north of England, the inspector was much struck by this homelike feeling as contrasted with the more formal atmosphere of hostels where all service is done by the staff. An objection may be made that women should rest during their meal intervals. In the hostels concerned, however, the tenants are not all on heavy work, and they can take turns in helping to serve. If a choice has to be made between allowing residents to have meals in the kitchen and having a combined dining and recreation room, the former is the better plan from many points of view, provided it works in well with the staff arrangements. In hostels where it is desirable to keep the staff apart from the tenants the arrangement would obviously be impossible. Everything depends on the character and spirit of the residents.

In large hostels a kitchen-dining room is not practicable, and economy of service could be effected by having two service-windows, or two sets of windows. The diners receive their food from one and put in used plates at the other. It is, however, difficult to get residents to return plates after use.

In a few houses there are service lifts. In old-fashioned houses there is the arrangement of basement kitchen and ground floor dining room. To do away with the inconvenience of this, the basement laundry or servants' hall is used for a dining room.

In some of the large Government hostels educated girls act as servers and canteen workers. They are paid the ordinary wage for this work, and their influence is very good. The food is better served, the crockery is more carefully used, and the tenants like to be skilfully waited on.

#### *Table Appointments.*

Table cloths are found to be an extravagance in hostels, as they become too quickly soiled. Many hostel owners are unwilling to dispense with them because they wish to maintain a good standard. This question of standard is a broad and difficult one, in whatever form it arises. It must be remembered that hostels are to some extent commercial concerns, and that owners must cater for the tastes of their tenants. Efforts to improve standards of accommodation and table manners must be made with extreme caution.

Good white American cloth fixed on to the tables is a satisfactory substitute for linen, for very rough men and women, a beading round the edges of the tables is advisable to prevent spilling on the floor. Small tables are much appreciated in some hostels.

#### *Hostels where the Tenants Cook for Themselves.*

These are, strictly speaking, lodging houses, but they are inspected when they house munition workers. The Welfare and Health Section is much opposed to the system of girls on munition work buying food and cooking it themselves in lodging houses. There are several grave objections, *e.g.* :—

1. They are apt to under-feed, through lack of time and energy to buy and cook food.
2. There are difficulties in cooking and larder accommodation.

The usual arrangement is to have a long stove, on which the residents can cook, in a small room off the mess-room. In old lodging houses there is the old-fashioned hot plate which consumes large quantities of fuel; in the more modern houses there is a gas stove. The panracks and food-lockers are usually arranged round the walls of this room. This is not ideal as the room is never cool, but food is usually bought in small quantities by lodgers. In one hostel for men the food-lockers are round the wall of the recreation room, a most undesirable arrangement.

The style of feeding adopted by lodgers varies infinitely. The following particulars are given as examples, but it must be remembered that only a few regular munition workers of the roughest type are involved.

1. In Edinburgh, in a combined lodging house and hostel, it was found that of 10 women of the hawker class, 5 were frying bacon and egg, bacon or sausage, for breakfast, and the other 5 were having tea, bread and butter or margarine with no meat dish.

2. In a women's lodging house at Hull the lodgers feed themselves on 1s. 3d. per day. For this they are only able to have meat twice a week. Typical meals are as follows:—

*Breakfast.* Bacon or kipper, tea, bread and margarine.

*Dinner.* Fried fish, tea, bread and margarine.

*Tea.* Bread and margarine, and tea.

On the days when meat is bought the women have only a cup of tea in the morning, and combine breakfast and dinner in the meat meal.

In a clearing hostel for Irish navvies in Yorkshire it is found that the men buy bacon for breakfast, and  $\frac{1}{2}$  lb. of meat (often steak) which they cook for supper, and take cold to the works next day.

In another lodging house for navvies the men buy provisions at a shop on the premises which is the private enterprise of the warden of the house. This arrangement is open to suspicion; it costs the men 17s. to 19s. per week to feed themselves in this lodging house.

The feeding of men in navy huts is receiving more attention now from enlightened managers. One managing contractor who had had experience of housing navvies in various parts of Scotland has decided to abolish the mess-room altogether, and to have the canteen only, so that he may have the feeding of the men under his own control. In this connection comfort in the canteen is of importance. Navvies are notoriously restless, but men who are comfortably fed are more likely to stay on the work, and managers are beginning to try the effect of more attractive surroundings.

#### *Costs of Catering.*

The following table has been drawn up to show estimated costs of catering at prices prevailing in November, 1917.

*Hostels.*—Estimated cost per head per week for "A" food only, consisting of breakfast, dinner, tea and supper; and "B" service, rent and other charges.

No.	"A" Food only a man.	"B" Service, rent and other charges.	"A" Food only a woman.	"B" Service, rent and other charges.
50	15s. 10d. + 5s. = 20s. 10d.		13s. 9d. + 5s. = 18s. 9d.	
100	14s. 6d. + 5s. = 19s. 6d.		13s. 2d. + 5s. = 18s. 2d.	
300	13s. 9d. + 5s. = 18s. 9d.		12s. 7d. + 5s. = 17s. 7d.	
500	12s. 6 $\frac{1}{2}$ d. + 5s. = 17s. 6 $\frac{1}{2}$ d.		11s. 2 $\frac{1}{2}$ d. + 5s. = 16s. 2 $\frac{1}{2}$ d.	
1000	11s. 11 $\frac{1}{2}$ d. + 5s. = 16s. 11 $\frac{1}{2}$ d.		10s. 8d. + 5s. = 15s. 8d.	

The above should cover all hostel costs, including rent, but no sinking fund.

### *Methods of Buying.*

Skilful buying combined with the most economical use of foodstuffs is the secret of successful catering.

Those hostels which are attached to a large factory have a great advantage in this respect in that buying is done centrally, and the hostel reaps the benefit of wholesale prices, and in some cases will avoid competition with other hostels. Large hostels have a similar advantage over small ones. There is, however, great scope for a matron's ability in retail buying, because prices often vary in different parts of the same town, although seeking out the best and cheapest shops is a severe tax on her time and strength. The difficulty and cost of transport has to be reckoned with if supplies are brought from a distance. If the hostel has a motor a great saving can be made. Good storage accommodation is essential if buying is done on a large scale.

In connection with buying comes up the question whether hostel managers should lay in stores of extras, such as fruit, chocolate, sweets, cakes, &c., to sell to tenants at advantageous prices. The sale of these is a source of revenue to hostels, but it is objected to by some on the ground that it means competition with the little shops outside. The answer is that the number of customers affected is too small to matter to the shopkeepers, and the question is one of finance.\* The only interest it has from the food point of view is that sweets bought for hostels would possibly be of better quality than those to be had outside.

### *The Prevention of Waste.*

Waste can be prevented in two ways:—

1. By making dishes so palatable that very little is left on the plates at meals.
2. By using up all scraps.

As has been said before, variety and attractiveness are the most difficult qualities to ensure in catering. Monotony in menus leads to food being left. Twice-cooked food soon becomes unpopular if served too often, and the traditional British method of cooking vegetables is unattractive in the extreme.

The second method, viz., using all scraps of food left, is carried out by most matrons according to their ability. In some places, if the tenants know what is being done in this way, they are apt to object on hygienic grounds. It was found in the case of two hostels under the same management, that in one the residents thought it unwholesome to use bones taken from the plates for the stockpot, while in the other hostel the tenants quite approved of it. Such difficulties can usually be overcome with tact. As to the ways in which saving is effected, it is found that educated cooks are the most enlightened and expert. All bones and scraps from plates, except starch scraps and green vegetables, can be used in the stockpot. Waste bread can be used without danger, if it is baked and grated. It can be mixed with flour for puddings, &c. In connection with methods of cooking it has been established by experiments made in King's College that slow cooking of meat in a gas oven effects a saving of 9 lbs. in every cwt. Experiments on the methods of cooking dried pulses have shown the economy of using the water in which these are cooked as a basis for stock or soup.

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\* It is now (January, 1918) understood that the Ministry of Food may prohibit the sale of sweets.

Lodging house feeding is very wasteful as no control can be kept over the tenants. Even in good class lodging houses it is found that a considerable amount of food is left to rot in food-lockers.

*A la carte catering* is a method of avoiding waste in so far as workers can choose what they wish to eat. This cannot be carried out in small hostels.

### *Hostel Diets and the Present Condition of the Food Supply.*

The question of continuing hostel diets on the present generous scale is a serious one owing to the shortage of food, and different distributions amongst the three classes of foodstuffs are being tried, notably the reduction of fats and increase of carbohydrate by a more plentiful use of potatoes. From a consideration of the circumstances, the action to be taken seems to lie rather with the matrons than with the tenants. It would be unsafe to appeal to munition girls to eat less, because they might possibly relapse into their former unprofitable habit of living on tea and buns, and the whole work of building up their standard of food would be undone, and their efficiency would be reduced. Matrons have tried rationing various articles and have had varying success. It is on the whole easier to carry out voluntary rationing in the northern hostels than it is in those in the south, because workers in the north have generally been poorer than southern workers and accustomed to harder fare.

It is felt that the best use of substitutes and the most economical use of food generally are matters which require a great deal of skill, and which may be beyond the powers of ordinary English cooks.

It is probable that if some highly expert help and advice were given to hostel cooks and caterers a great saving would be made. An expert chef could give valuable advice on the best way of cutting up meat, and also on the preparation of attractive dishes. The matrons can and do effect a great deal in the way of appealing to their own tenants not to waste food, and in advising them to eat appropriate food, but the greatest economy they can effect is to provide such appetising meals in the hostel that residents will not desire to supplement them outside. Food bought outside at odd times is wasteful, both in nourishment and cost.

Now that the times have become more difficult, matrons find it to their advantage to avail themselves of official advice about catering both as to the number of calories they should provide and the proper distribution among the three classes of foodstuffs. There has been a certain tendency to regard the food returns as a Government fad, but the hostel section are making their value more appreciated by showing how they can be used as the basis of practical advice.\*

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\* *Note added 29.1.18*—Owing to the changed food conditions of the country, the details in the above account no longer fully correspond to actual practice.





